MISCELLANEOUS PAPER S-69-29

EVALUATION OF HARVEY NONWELDED ALUMINUM LANDING MAT

by

C. D. Burns

R. W. Grau

July 1969

Sponsored by

Naval Air Engineering Center
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13. ABSTRACT

This investigation was conducted to evaluate the performance of the 1- and 2-ft-wide Harvey nonwelded aluminum landing mats and to compare the performance with that obtained in previous tests on standard AM2 mat. This landing mat was extruded by the Harvey Aluminum Co., Torrance, Calif. Three test sections were built and surfaced with different shipments or types of Harvey mat. The first and second sections were surfaced with 1- by 6-ft and 2- by 6-ft mat, respectively, each over two clay subgrade items with different CBR strength values. The third section consisted of two items surfaced with 2- by 12-ft and modified 2- by 12-ft mat over a subgrade of the same nominal strength as the lower subgrade strength of the first and second sections. All three test sections were subjected to uniform-coverage traffic, and section one was also subjected to single-line traffic. The traffic represented operations of an aircraft having a 60,000-lb gross weight with a single-wheel main-gear assembly load of 27,000 lb with a 30-7.7 tire inflated to 400 psi. Based on the results obtained in this study, it is concluded that: (a) the Harvey 1- by 6-ft, 2- by 12-ft, and modified 2- by 12-ft nonwelded aluminum mats will sustain 1600 cycles (188 coverages) of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on subgrades having minimum CBR's of 3.7, 4.2, and 4.4, respectively, or greater throughout the period of traffic; (b) the Harvey 1- by 6-ft nonwelded aluminum landing mat will sustain 1600 passes of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi in a single path located 1-1/2 ft or more from the mat end joints when placed on a subgrade having a CBR of 4.6 or greater throughout the period of traffic; (c) the two sections of 2- by 6-ft nonwelded mat failed early in the traffic period due to extrusion defects and not to the nonwelded joint configuration; (d) the main difference between the performance of the 2- by 12-ft mat and that of the modified 2- by 12-ft mat was that the modified planks shifted more laterally during traffic; (e) compared with AM2 mats previously tested at the WES, the 1- by 6-ft mat will sustain 188 coverages of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure on a lower subgrade strength, but the 2- by 12-ft Harvey nonwelded mat requires a slightly higher subgrade strength to sustain 188 coverages of traffic.

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ASSOCIATED REPORTS

Report No.	Title	Date
MP 4-501	Development of CBR Design Curve for M9M2 Landing Mat	June 1962
MP 4-581	Evaluation of M9M1 Landing Mat	July 1963
MP 4-599	Development of CBR Design Curves for AM1 Landing Mat	Sept 1963
MP 4-615	Development of CBR Design Curves for Harvey Aluminum Landing Mat (AM2)	Jan 1964
MP 4-655	Development of CBR Design Curve for Modified AM1 Landing Mat	June 1964
MP 4-656	Evaluation of Convair Landing Mat	June 1964
MP 4-747	Evaluation of Harvey Modified AM2 Landing Mat	Oct 1965
MP 4-753	Evaluation of Washington Aluminum Company AM2 Landing Mat	Jan 1966
MP 4-786	Evaluation of Various Sizes of Harvey Aluminum AM2 Landing Mat	Jan 1966
MP 4-787	Evaluation of Various Sizes of Butler AMl Landing Mat	Jan 1966
MP 4-788	Evaluation of AM2 Landing Mat Replacement Panels and Keylock Assemblies	Jan 1966
MP 4-789	Evaluation of Butler AM2 Landing Mat	Feb 1966
MP 4-850	Evaluation of Guide Rail in Conjunction with Kaiser and Harvey Landing Mat (AM2)	Oct 1966
MP 4-852	Evaluation of Harvey Two-Piece Landing Mat (AM2)	Nov 1966
MP 4-886	Evaluation of Three-Piece AM2 Aluminum Landing Mat	Apr 1967
MP 4-954	Comparative Performance Tests of AM2 Mat from Various Extruders and Fabricators	Dec 1967
MP S-68-11	Evaluation of May Two-Piece AM2 Landing Mat	July 1968
MP S-69-3	Evaluation of Washington Aluminum Company, Inc., Production AM2 Landing Mat	Jan 1969
MP S-69-13	Evaluation of Harvey Electron Beam Welded AM2 Landing Mat (AM2 MOD 2)	Jan 1969

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FOREWORD

This report is the 20th in a series published on landing mat tests performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the Naval Air Engineering Center (NAEC), Philadelphia, Pa. The investigation reported herein was authorized by the NAEC in Project Order No. 6-4031, dated 3 December 1965, and was conducted by the WES during the period June-October 1967.

Engineers of the Soils Division who were actively engaged in the planning, testing, analyzing, and reporting phases of the investigation were Messrs. R. G. Ahlvin, C. D. Burns, R. W. Grau, and M. J. Mathews, under the general supervision of Messrs. W. J. Turnbull and A. A. Maxwell, Chief and Assistant Chief, respectively, of the Soils Division. This report was prepared by Messrs. Burns and Grau.

COL John R. Oswalt, Jr., CE, and COL Levi A. Brown, CE, were Directors of the WES during the conduct of the investigation and preparation of this report. Messrs. J. B. Tiffany and F. R. Brown were Technical Directors.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square inches	6.4516	square centimeters
ounces	28.3495	grams
pounds	0.45359237	kilograms
kips	453.59237	kilograms
pounds per square inch	0.070307	kilograms per square centimeter
pounds per square foot	4.88243	kilograms per square meter
pounds per cubic foot	16.0185	kilograms per cubic meter

SUMMARY

This investigation was conducted to evaluate the performance of the 1- and 2-ft-wide Harvey nonwelded aluminum landing mats and to compare the performance with that obtained in previous tests on standard AM2 mat. This landing mat was extruded by the Harvey Aluminum Co., Torrance, Calif.

Three test sections were built and surfaced with different shipments or types of Harvey mat. The first and second sections were surfaced with 1- by 6-ft and 2- by 6-ft mat, respectively, each over two clay subgrade items with different CBR strength values. The third section consisted of two items surfaced with 2- by 12-ft and modified 2- by 12-ft mat over a subgrade of the same nominal strength as the lower subgrade strength of the first and second sections. All three test sections were subjected to uniform-coverage traffic, and section one was also subjected to single-line traffic. The traffic represented operations of an aircraft having a 60,000-lb gross weight with a single-wheel main-gear assembly load of 27,000 lb with a 30-7.7 tire inflated to 400 psi.

Based on the results obtained in this study, it is concluded that:

a. The Harvey 1- by 6-ft, 2- by 12-ft, and modified 2- by 12-ft nonwelded aluminum mats will sustain 1600 cycles (188 coverages) of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on subgrades having minimum CBR's of 3.7, 4.2, and 4.4, respectively, or greater throughout the period of traffic.

b. The Harvey 1- by 6-ft nonwelded aluminum landing mat will sustain 1600 passes of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi in a single path located 1-1/2 ft or more from the mat end joints when placed on a subgrade having a CBR of 4.6 or greater throughout the period of traffic.

c. The two sections of 2- by 6-ft nonwelded mat failed early in the traffic period due to extrusion defects and not to the nonwelded joint configuration.

d. The main difference between the performance of the 2- by 12-ft mat and that of the modified 2- by 12-ft mat was that the modified planks shifted more laterally during traffic.

e. Compared with AM2 mats previously tested at the WES, the 1- by 6-ft mat will sustain 188 coverages of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure on a lower subgrade strength, but the 2- by 12-ft Harvey nonwelded mat requires a slightly higher subgrade strength to sustain 188 coverages of traffic.

EVALUATION OF HARVEY NONWELDED ALUMINUM LANDING MAT

PART I: INTRODUCTION

BACKGROUND

1. For several years the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., has been engaged in a study for the Naval Air Engineering Center (NAEC), Philadelphia, Pa., for the purpose of evaluating various types of landing mats to be used in surfacing small airfields for tactical support (SATS) in combat air operations. A SATS has been defined as a small, quickly constructed, temporary, tactical support airfield, capable of sustaining operations of the Marine Corps' modern jet aircraft, which employ assisted takeoffs and arrested landings.

2. The service criterion established by NAEC for landing mat is that it remain in serviceable condition with minimum maintenance for at least 1600 aircraft operation cycles (a cycle is one takeoff and one landing) during a 30-day period when placed on a subgrade having a CBR of 10 or less.* The heaviest proposed Marine Corps aircraft that will utilize SATS weighs 60,000 lb** (27,000 lb per main gear wheel) and is equipped with 30-7.7, 18-ply rating (PR) tires inflated to 400 psi. Therefore, for the evaluation of various landing mats considered for use in SATS, NAEC has standardized the test load at 27,000 lb on a single wheel with a 30-7.7, 18-PR tire inflated to 400 psi. NAEC requires that a test section of the particular mat under consideration, when placed on a subgrade having a CBR of 10 or less, remain serviceable with minimum maintenance for (a) 188 coverages (equivalent to 1600 cycles) of the test load applied uniformly over a 10-ft-wide traffic lane, and (b) 1600 passes of the test load applied in a single path (one tire print width). The uniform-coverage traffic simulates landings and normal takeoffs in which no catapult is used, and the single-path traffic simulates takeoff runs in which a catapult system is employed.

3. All AM2 landing mats previously tested at WES for NAEC have been fabricated from aluminum extrusions onto which the end-joint connectors were welded to form a plank. Although the mats constructed in this manner have met minimum performance standards, the majority of the plank failures were due to weld breaks between the aluminum extrusions and the end-joint connectors. The end-joint weld failures, therefore, were an effective influence on the service life of the AM2 mat. In an effort to improve the service life of the mat, Harvey developed an aluminum mat with a nonwelded end joint that was tested in this investigation.

4. For this investigation, the NAEC procured small quantities of 1- and 2-ft-wide nonwelded mat fabricated from single extrusions by Harvey Aluminum Co., Torrance, Calif.

OBJECTIVE AND SCOPE OF INVESTIGATION

5. The objective of this investigation was to evaluate the performance of Harvey 1- by 6-ft, 2- by 6-ft, 2- by 12-ft, and modified 2- by 12-ft nonwelded landing mat and to compare the performance with

* These tests were made during a transition period for the subgrade strength requirement. It was anticipated that the 10-CBR requirement would be lowered for future tests on landing mat; therefore, the mats in this investigation were placed on subgrades having CBR's of 4 and 7.

** A table of factors for converting British units of measurement to metric units is presented on page vii.

that of standard AM2 mats previously tested under accelerated traffic with loadings contemplated under the SATS concept.

6. The objective of the tests was accomplished by:

a. Constructing three test sections that consisted of different subgrade strengths, and surfacing the sections with 1- by 6-ft, 2- by 6-ft, or 2- by 12-ft mat.

b. Performing accelerated traffic tests with a 27,000-lb single-wheel load on a 30-7.7, 18-PR tire inflated to 400 psi.

c. Observing the behavior of the mat and subgrade during traffic tests and recording pertinent test data.

d. Analyzing the performance and data from the nonwelded mat test and comparing the test results with those obtained in previous tests on standard AM2 mats.

This report describes the landing mat, test sections, tests conducted, and results obtained, and presents an analysis of the test data.

DEFINITIONS OF TRAFFIC TERMS

7. Traffic terms having special meaning in this report are defined below:

a. *Cycle.* One takeoff and one landing of an aircraft. For this investigation, a cycle is considered one round trip or two passes of the test vehicle over the mat.

b. *Pass.* One traverse of a load wheel along a given length of runway, taxiway, or test section surface. In this investigation, load repetitions applied in a single path (one tire print width) are referred to as passes. The repetitious loads resulting from aircraft taking off over the same path when a catapult system is used are simulated on a test section by the application of the test load in repeated passes along a single line or path, e.g. 1600 cycles of an aircraft involves 1600 takeoffs or passes over the same path.

c. *Coverage.* One application of the wheel of an aircraft or test load vehicle over the entire area of the test lane being subjected to traffic. Since the traffic is applied incrementally in passes, and the width of each pass is equal to one tire print width, the number of passes required to complete one coverage is equal to the test lane width divided by the tire print width.

PART II: TEST VEHICLE AND TESTS CONDUCTED

TEST LOAD CART

8. A specially designed single-wheel test cart (fig. 1) loaded to 27,000 lb was used in the traffic tests. It was equipped with an outrigger wheel to prevent overturning, and was powered by the front half of a four-wheel-drive truck. The test wheel was equipped with a 30-7.7, 18-PR tire inflated to 400 psi. With the 27,000-lb wheel load, the tire had a contact area of about 82 sq in. and an average contact pressure of 330 psi.

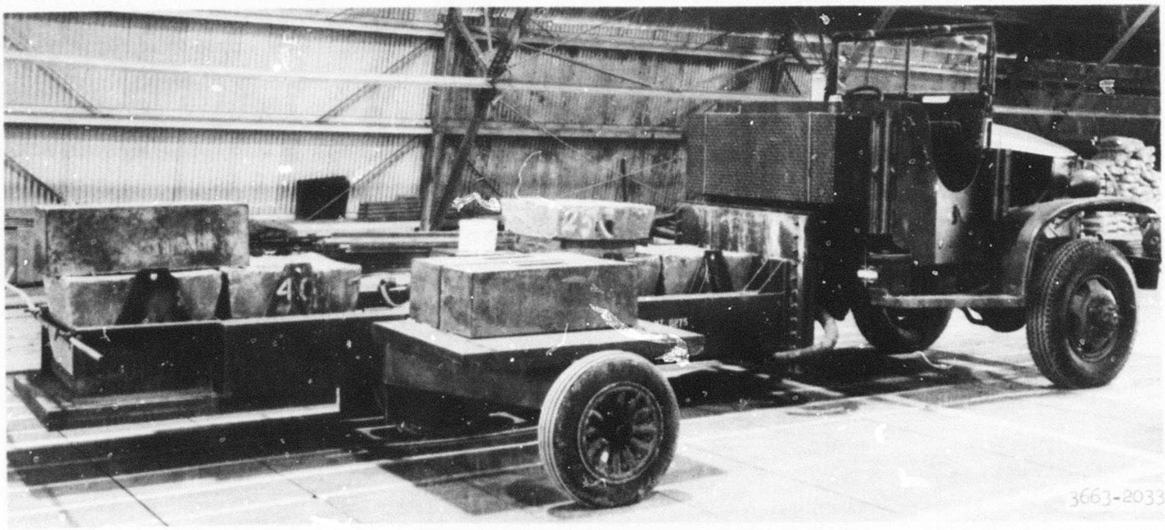


Fig. 1. Test load cart

TRAFFIC TESTS

Uniform-Coverage Traffic

9. Uniform-coverage traffic was applied in a 10-ft-wide traffic lane on each test section to simulate the traffic distribution pattern of a main landing gear wheel that would occur on a mat surface during landings and normal takeoffs when no catapult was used. Traffic was applied by driving the load cart forward and then backward over the length of the test section, shifting the path of the cart laterally about 7 in. (one tire print width) on each forward pass. This procedure resulted in two complete coverages of traffic on the test lane each time the load cart was maneuvered from one side of the lane to the other. Anchor weights were placed at 4-ft intervals on each edge of the mat to prevent lateral movement of the mat, as shown in photograph 1.

Single-Line Traffic

10. In aircraft launching operations employing a CE-type catapult, the aircraft is always launched from the same position on the runway, and the wheels of each aircraft follow essentially the same path on every takeoff. To simulate this type of loading, traffic was applied in a single path on a line approximately 2-1/2 ft outside the uniform-coverage traffic lane and 7-1/2 ft from the east edge of the mat, as shown in plate 1. Traffic was continued on each item in test section 1 until 1600 passes had been

completed. For this traffic, the weights along the east edge of the mat were removed because NAEC desired that the mat edge not be restrained during traffic. Single-line traffic was not applied to test section 2, 2a, or 3.

SOIL TESTS AND MISCELLANEOUS OBSERVATIONS

11. Water content, density, and in-place CBR tests were conducted prior to traffic and at failure or at the end of traffic in each test item. The tests were made at depths of 0, 6, and 12 in., and at least three tests were made at each depth. The data obtained from the tests are summarized in table 1. The values listed in table 1 for each of the various depths are averages of the values measured at that depth.

12. Visual observations of the behavior of the test items and other pertinent data were recorded throughout the traffic test period. These observations and data were supplemented by photographs. Level readings were taken on the mat prior to and at intervals during traffic to show the development of permanent mat deformation and total deflection of the mat under the wheel load.

FAILURE CRITERIA

13. The criteria for mat failure were the same as those used in previous tests of this series and are based primarily on mat breakage. It was assumed that a certain amount of maintenance would be performed in the field during actual usage and that minor metal breaks could be easily repaired. However, in this test when the C-rail side and ribs of the plank split, the mat plank was considered failed beyond repair. Although this type of failure cannot be seen while the mat is in the test section, the possibility that it exists is often indicated by skin tears and/or a loud crackling noise as the test cart rolls over the mat planks.

14. In previous tests it was considered feasible to replace up to 10 percent of the mat planks with new mat during the design service life of a runway; however, replacement in excess of 10 percent of the planks is not considered practical. Therefore, it was assumed that in each test item up to 10 percent of the planks could be replaced, and when an additional 10 percent of the planks had failed (a total of 20 percent failed), the entire item was considered failed. In test 1, no mat planks had failed at the end of 188 coverages of uniform-coverage traffic or 1600 passes of single-line traffic. Therefore, no planks were replaced. After the minimum uniform-coverage and single-line traffic had been applied to the test section with no failures occurring, the uniform-coverage traffic was continued until the section failed.

IDENTIFICATION OF TYPES OF MAT BREAKAGE

15. The Harvey nonwelded mat tested in this investigation is of a different design from other mats tested for NAEC. Therefore, a different notation for breaks was needed. Below are the designations and descriptions of the breaks observed in this mat.

a. *C-rail split.* A split or tear in the vertical rib of the C-rail side connector usually occurring in the top section of the vertical rib. This type break is shown in photograph 2. The plank is shown upside down in order to give a better view of the torn C-rail side connector.

b. *End-curl split.* A split or tear in the nonwelded end connectors, which usually occurred in the top curl of the end connector, is shown in photograph 3. This plank is also upside down.

PART III: TEST SECTIONS AND MATS

TEST SECTIONS

Location

16. The traffic tests were conducted at the WES on special test sections that were constructed and subjected to traffic under shelter in order to control water content and strength of the subgrade soil.

Description

17. Layouts of test sections 1-3 are shown in plates 1-3, respectively. Test sections 1 and 2 consisted of two items each, and test section 3 consisted of three items. The items in the first two test sections were approximately 30 ft wide and 20 ft long, and those in the third test section were approximately 24 ft wide and 40 ft long. The subgrades in all three test sections were constructed of a heavy clay soil. Classification data for the subgrade soil are shown in plate 4. The 1- by 6-ft mat was used to surface both items of test section 1. The subgrade of test section 2 was used twice; different shipments of 2- by 6-ft mat were used each time to surface the section. The items in test section 3 were surfaced with Harvey 2- by 12-ft basic and modified nonwelded landing mat.

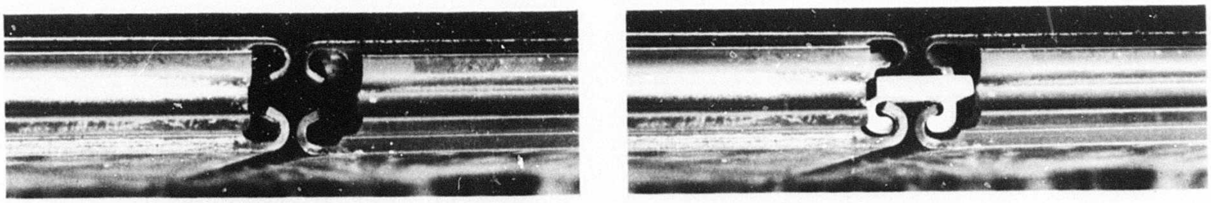
Subgrade Construction

18. The subgrades for all test sections were to be constructed to a total thickness of 24 in.; therefore, the existing material at the test site was excavated to a depth of 24 in. below the finished grade, and the excavation was backfilled with special test soils. The soil beneath the excavation was a heavy clay having a CBR value of approximately 10. The soil for each test item was processed separately to the water content that would yield the desired CBR when compacted, hauled to the test site by truck, spread, and compacted in 6-in.-thick lifts. Compaction of each lift was accomplished by applying eight coverages of a self-propelled rubber-tired roller loaded to 35,000 lb with its tires inflated to 65 psi. The surface of each lift was scarified prior to the placement of the next lift. After placement and compaction of the fourth and final lift, the surface of the subgrade was fine-bladed to grade by a motor patrol.

MATS TESTED

Description

19.. Both the 1- and 2-ft-wide planks were fabricated from a single extrusion. Nonwelded integral end-connector joints were formed on each end of the mat planks by curling in the upper and lower surfaces after the basic planks had been extruded. Details of the end-joint and locking-bar assembly are shown in fig. 2. The only difference between the nonwelded AM2 and standard AM2 mat is the type of end



a. Planks with nonwelded end connectors butted together to receive locking bar

b. Planks connected with a locking bar

Fig. 2. Details of end-joint and locking-bar assembly

connector on each mat. The dimensions of mat planks used on the various test sections were as follows:

Type of Plank	Section No.	Item No.	Width ft	Length ft	Thickness in.	Weight: Per Plank lb	Weight: Per Square Foot of Placing Area, lb
1 by 6	1	1, 2	1.00	6	1-1/2	38.0	6.33
2 by 6							
1st shipment	2	1, 2	2.08	6	1-1/2	71.0	5.69
2d shipment	2a	1, 2	2.08	6	1-1/2	69.7	5.58
2 by 12							
Modified	3	2	2.08	6	1-9/16	70.2	5.63
				12	1-9/16	140.2	5.62
Basic	3	3	2.08	6	1-9/16	70.1	5.62
				12	1-9/16	140.4	5.63

20. The modification of the male side connector and locking bar is the only difference in the 2- by 12-ft mats. The full-sized planks were modified by cutting a 1-1/2-in. notch out of the center portion of the male side connector. Also, the locking bars used with the modified mats had 1-in. web extensions on both ends of the bars instead of on just one end, as did those used with the regular nonwelded mats. This 1-in. extension fits into the notch of the male side connector of the planks in the preceding run. Figs. 3 and 4 show close-ups of two end joints, a locking bar, and a notched plank in position before being assembled and after being partially assembled, respectively. A 1- by 6-ft mat plank and a locking bar are shown in

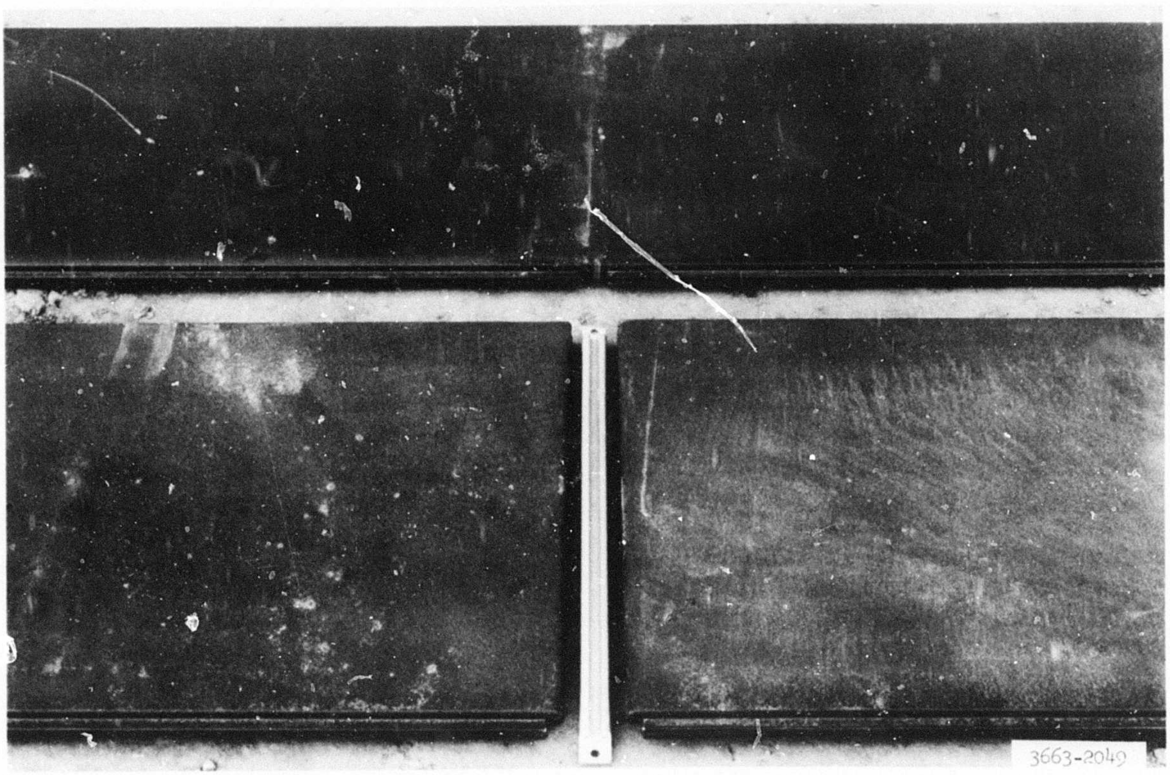


Fig. 3. Modified mat and locking bar before assembly

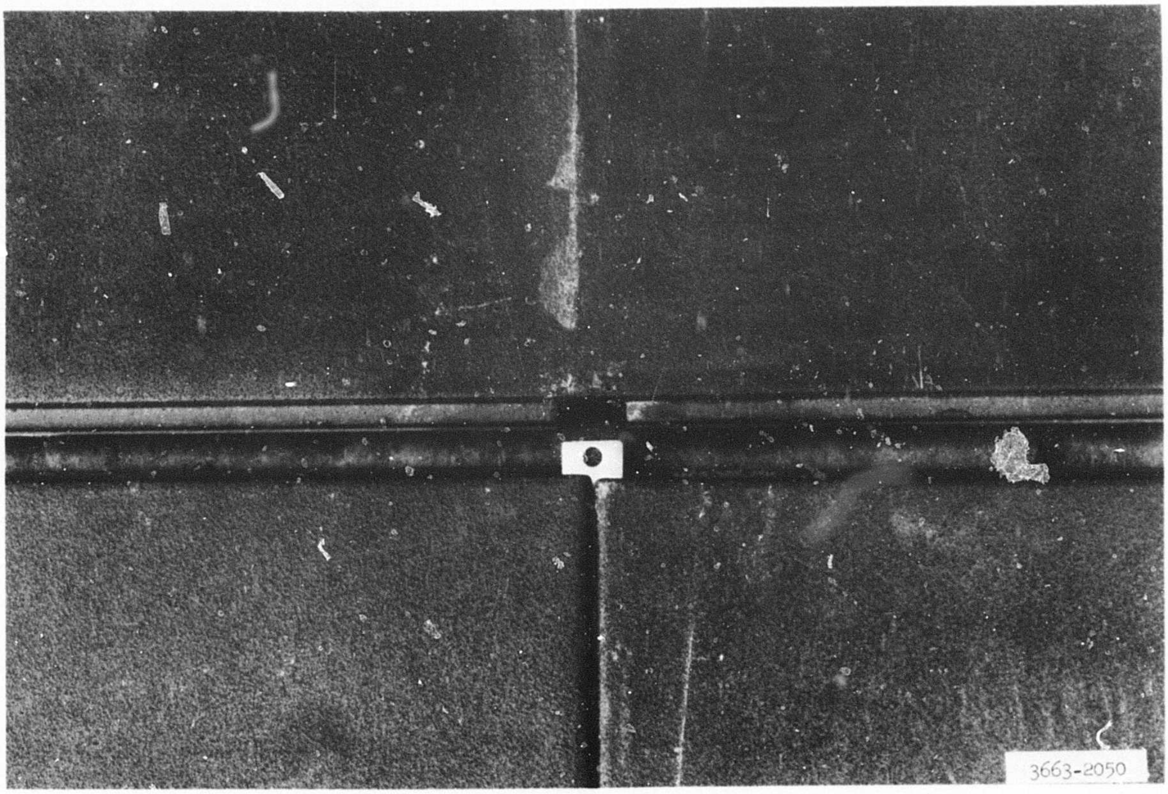


Fig. 4. View showing how the 1-in. web extension of the locking bar fits into the notched male side connector

photograph 4, and a 2- by 6-ft mat plank and a locking bar are shown in photograph 5. Photograph 6 shows a locking bar and one full-size and one half-size plank of the modified 2- by 12-ft mat.

Placement Procedures

21. A T16 membrane underlay was used in this investigation to help prevent drying of the subgrade soil and to maintain constant subgrade strength. T16 is a neoprene-coated 3.2-oz nylon membrane weighing approximately 0.13 psf. Photograph 7 shows the subgrade covered with T16 membrane.

22. After the placement of the membrane, the mat was placed on the test section by a crew of experienced laborers under the supervision of a foreman. The mat bundles were placed beside the test section with a forklift, and the individual planks were carried a distance of about 30 ft by laborers and placed in position. One laborer inserted locking bars between the planks at the end joints.

23. The test sections were surfaced with different types of mat as described in paragraph 19. The planks were placed with the long axis perpendicular to the direction of traffic, as shown in plates 1-3. A staggered end-joint configuration for the 6-ft-long mat was obtained by placing four mat planks in the first run and five in the second run of mat. A staggered end-joint configuration was formed with the 12-ft-long mat by use of half planks in alternating runs. The edges of the surfaced section were uneven when the 6-ft mat was used and even when full and half planks of the 12-ft mat were used.

PART IV: BEHAVIOR OF MAT UNDER TRAFFIC

TEST SECTION 1, 1- BY 6-FT MAT

Uniform-Coverage Traffic

24. A general view of test section 1 is shown in photograph 1. After 10 coverages, the ends of the mat were slightly curled due to the planks flexing under traffic. At 48 coverages, the mat had moved longitudinally causing a slight bow in the transverse joints. There was approximately 2-1/2 in. of bow, as shown in photograph 8, due to the longitudinal movement of the mat after 100 coverages. Planks 27, 31, and 32 in item 1 showed a dish of about 3/16 in. along the center line after 150 coverages.

25. Item 1 was in fair condition and item 2 was in good condition at 188 coverages. The only apparent damage observed at this time was the curl of the end connectors on 11 planks in item 1 and 4 planks in item 2. Photograph 9 shows the test section after 188 coverages of traffic. Twenty-seven planks were taken up in item 1 after 188 coverages in order that the CBR could be checked and a partial break count could be taken. There were 31 C-rail splits out of 32 possibilities in the 27 planks inspected. These splits varied in length from 3/4 to 4 in. with an average of about 2-1/4 in. These small breaks could not be detected until the mat was taken up and would not have caused any operational problems.

26. Traffic was continued on the test section to 298 coverages, at which time item 1 was considered failed. Although the top surface of the mat was in fair condition at 298 coverages, interior breakage of the mat was evidenced by skin tears and loud crackling noises as the load cart passed over the broken planks. The only visible damage in item 1 after 298 coverages was small top skin tears, as shown in photograph 10, which appeared on nine planks, and two planks showed end-curl splits. All the end connectors in both items had a small amount of curl but not enough to cause a traffic hazard. A general view of the test section at failure is shown in photograph 11.

27. The mat was taken up and inspected after 298 coverages. The mat damage found in item 1 during this inspection was 60 C-rail splits varying in length from 2-1/4 to 8-1/4 in. and averaging 5-1/8 in., 20 end-curl splits about 1 in. long, and 51 ends of the planks in the traffic lane with one to six interior ribs broken. Ten of these planks were considered failed due to large C-rail splits and broken interior ribs at the end joints. The damage recorded in item 2 was 54 C-rail splits varying in length from 1 to 6 in. and averaging 3-3/8 in., 4 end joints with end-curl splits of about 1 in., and 21 planks with one to six broken interior ribs. There were two plank failures in this item due to C-rail splits and broken ribs.

28. Level readings were taken prior to, during, and after traffic. These data indicate that the greatest permanent deformation occurred in item 1. The maximum deformation measured was 0.6 and 0.5 in. for items 1 and 2, respectively, at the end of 188 coverages of traffic. After 298 coverages of traffic, the maximum deformation had increased to about 1.2 in. in item 1 and to 0.7 in. in item 2. A plot indicating deformation along the center line of the traffic lane is shown in plate 5.

Single-Line Traffic

29. The anchor weights were removed from the east edge of the mat before single-line traffic was applied. The traffic lane was located 1-1/2 ft from mat end joints. A general view of item 1 prior to traffic is shown in photograph 12. The mat planks had to be realigned at 760 passes as a result of lateral movement. Both items in the test section withstood 1600 passes of traffic with no apparent mat damage. A view of the test section after traffic is shown in photograph 13. The permanent mat deformation as determined from level readings taken at the end of traffic was 0.4 in. in item 1 and 0.2 in. in item 2.

A profile of mat deformation along the traffic path is shown in plate 6.

TEST SECTIONS 2 AND 2a, 2- BY 6-FT MAT

Section 2 - First Shipment

30. After 12 coverages of traffic, the mat planks in item 1 were dished from 3/8 to 1/2 in. The dish in the mat planks in item 2 ranged from 1/8 to 1/4 in. Photograph 14 shows the dish in plank 2 after 16 coverages. This dishing was caused by defects in the internal ribs, not by the nonwelded joint configuration. Therefore, traffic was stopped after 16 coverages of traffic upon the request of a Harvey representative with the concurrence of WES and NAEC. The mat was then taken up and shipped back to the factory for inspection by the fabricator. Harvey replaced this mat with new 2- by 6-ft nonwelded mat for further tests.

Section 2a - Second Shipment

31. No external damage was noticed in item 1 from 0 coverages to the time the test was stopped at 26 coverages. After 8 coverages of traffic, plank 40 in item 2 showed signs of severe internal damage, i.e. rib damage, and at 12 coverages, plank 38 showed signs of slight internal damage. Both planks 38 and 40 were replaced after 16 coverages because of internal damage, as shown in figs. 5 and 6. Internal failure in plank 40a, the replacement for plank 40, was noticed after two coverages of traffic. These failures were also caused by extrusion defects instead of the nonwelded joint configuration. Since this test program was mainly concerned with evaluating the performance of the nonwelded end connectors of the mat and not the

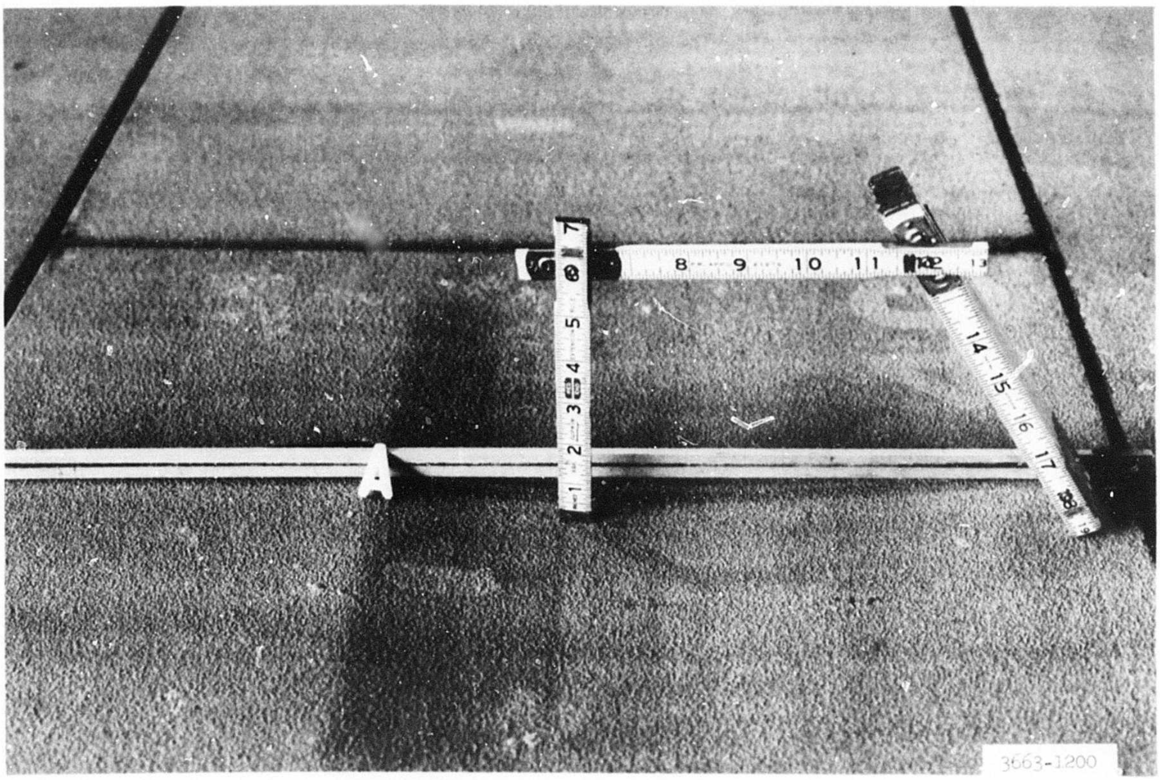


Fig. 5. Indicated internal damage in plank 40 after 16 coverages

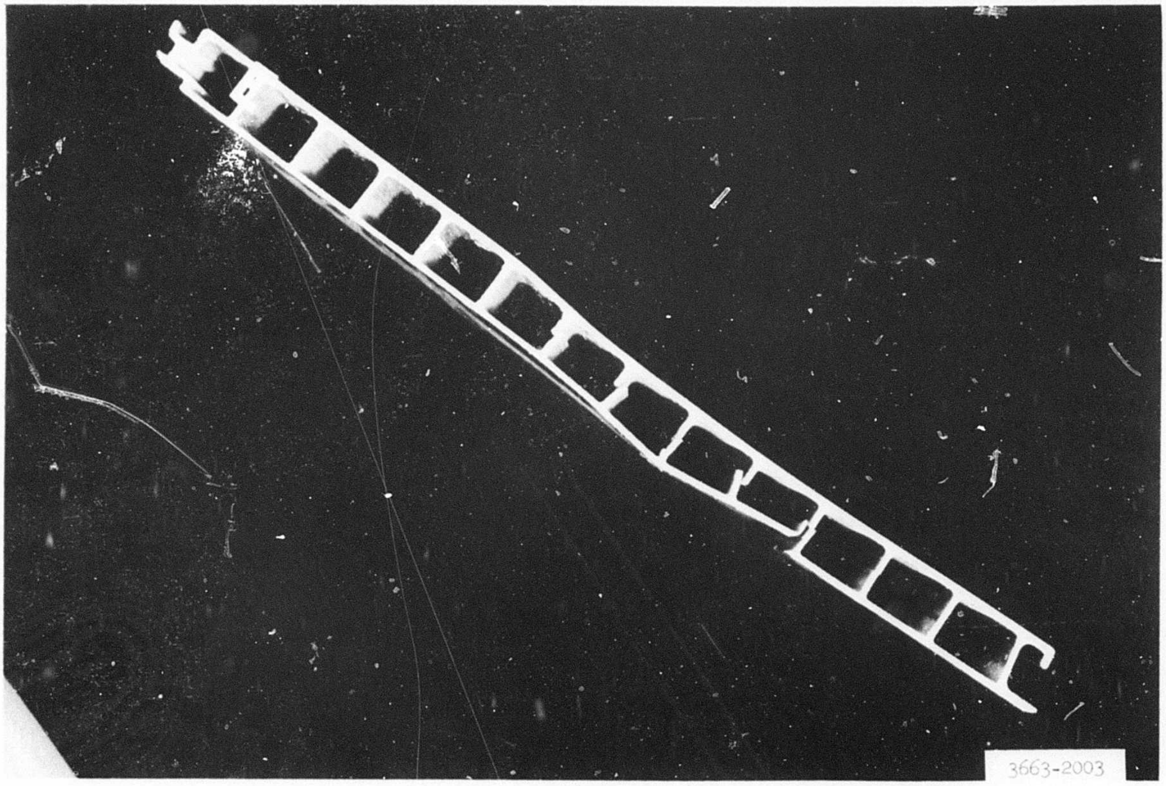


Fig. 6. Rib damage in plank 40 after 16 coverages

other properties of the mat, the test was stopped at 26 coverages. The mat was then taken up and shipped back to the fabricator at the request of NAEC.

TEST SECTION 3, 2- BY 12-FT MAT

2- by 12-ft Modified Design

32. A general view of item 2 prior to traffic is shown in photograph 15. Severe dishing in the mat occurred in runs that consisted of two full planks where the end joints were coincident with the center line of the traffic lane. Severe dishing and broken ribs were noted at the ends of the planks. This damage was caused by the reduced stiffness inherent in the design of the nonwelded end joints, not by breaks or shears of the end joints themselves; i.e., the integral end connectors appeared to be more flexible than the standard welded end connectors. After 10 coverages, a dish of 3/16 in. had developed at the end joints of planks 43 and 55. As the traffic test progressed, the dish in the mat increased. When traffic was stopped at 187 coverages, the dish in the 20 planks with end joints at the center of the traffic lane was approximately 1/2 in. The only other visible mat damage was an 11/32-in. skin tear on plank 43.

33. Although there was only one break on the top surface of the mat after 187 coverages, this item was considered failed due to severe dishing, which caused a very rough surface. The mat in this condition is a safety hazard when used with a catapult system because of the possibility of the arresting hook on the aircraft catching mat edges rather than the cable. Photograph 16, depicting item 2 after 187 coverages, shows that there was very little lateral movement of the mat planks during the course of 187 coverages of traffic. Lateral movement of the mat was prevented in this item by the web extrusion of the locking

bar (fig. 4) fitting into the notch cut in the male side connector of the plank in the adjacent run. Fig. 7 shows a close-up of the mat damage at a notch after 187 coverages of traffic. At the end of traffic, there were only five planks with breaks such as those labeled 1 and 3 in fig. 7, and one plank with a break such as that labeled 2 in fig. 7. These breaks were approximately 1 in. in length. Other damage that was observed when the mat was taken up was 18 C-rail splits that averaged 7-3/4 in., the longest being 13-1/2 in., and 1 to 12 ribs broken in 19 planks. The maximum deformation measured in item 2 after traffic was 0.5 in. A plot of deformation along the center line of the traffic lane is shown in plate 7.

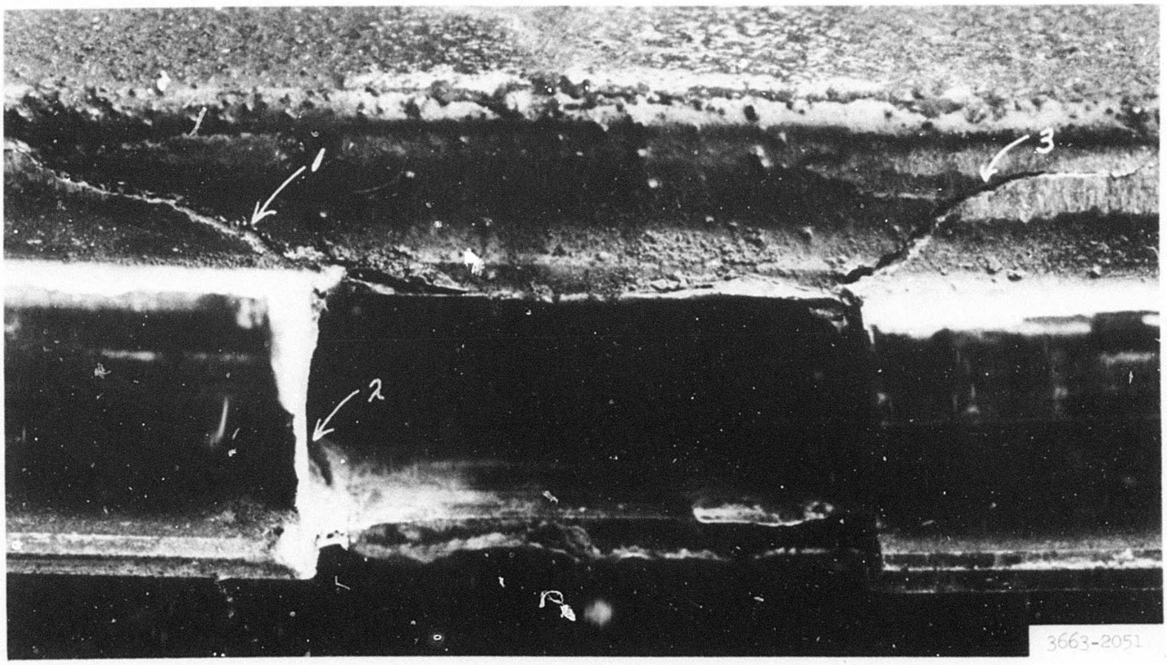


Fig. 7. Damage at notch in the modified mat at 187 coverages

2- by 12-ft Basic Design

34. A general view of item 3 prior to traffic is shown in photograph 17. After 10 coverages, a maximum dish of 3/16 in. was measured in this item on several mat planks with end joints in the traffic lane. At 14 coverages, the top lip of the C-rail at the end joints had begun to curl up on the mat planks. The largest curl measured was 7/32 in. The first mat breakage occurred at 58 coverages when a small crack appeared in the C-rails of planks 83 and 84. After 68 coverages, photograph 18 was taken showing the lateral movement of the mat planks in this item as opposed to very little movement in item 2. A popping noise, which usually indicates internal damage, was heard at 100 coverages of traffic as the test cart rolled up and down the item across the end joints. Fifteen of the twenty end joints in the traffic lane had broken C-rails at this time. Dishing had developed in all the planks with end joints in the traffic lane, with a maximum dish of 3/8 in. measured in three planks. The only other damage observed after 100 coverages was a small skin tear on plank 84. After 120 coverages, seven planks were in poor condition due to dishing, skin tears, and the curling of the upper lip of the C-rail. The dish in these planks ranged from 3/8 to 1/2 in., the average length of the skin tears was 1/2 in., and the height of curl was approximately 1/2 in. At 160 coverages, this item was considered failed. A general view of item 3 at failure is shown in photograph 19.

35. When traffic was stopped, the top skins of 16 planks were slightly torn, all 20 of the end joints in the traffic lane had curled top lips of the C-rail such as that shown in photograph 20, and there were 19 C-rail splits averaging approximately 7-1/4 in. in length. Ten planks were failed due to a dish of 1/2 in. or more. The dish in plank 103 after 160 coverages, which indicated rib failure, is shown in photograph 21. During the inspection after traffic, 18 planks (all in the even-numbered runs) were found to have 4 to 12 broken ribs at the end joints. The maximum mat deformation measured in item 3 after traffic was 0.4 in. A plot of deformation along the center line of the traffic lane is shown in plate 7.

PART V: ANALYSIS OF TEST RESULTS

TEST SECTION 1, 1- BY 6-FT MAT

Uniform-Coverage Traffic

36. *Test results.* A summary of the test results for lane 1 is presented in table 2. Included in the table are the rated subgrade CBR, mat breakage and deflection data taken at various stages of traffic, and the performance rating of the various test items based on the failure criteria described in paragraph 13. The rated CBR's for the clay subgrade, based on the numerical average of the CBR values measured at 0-, 6-, and 12-in. depths prior to and at the end of the traffic period, were 4.2 and 7, for items 1 and 2, respectively.

37. Items 1 and 2 withstood 188 coverages without failure. Traffic was stopped on both items at 298 coverages when item 1 was considered failed. This failure was due to rib failures and to C-rail splits, which were located at the end joints. All 50 planks in the 10-ft-wide traffic lane of item 1 had C-rail splits, and 51 plank ends had one to six broken interior ribs. Item 2 had 46 planks and 56 plank ends subjected to traffic. At the end of traffic, there were 54 C-rail splits, and 21 plank ends had one to six broken ribs. It should be noted that all failures and breaks that occurred during uniform-coverage traffic were located at end joints.

38. *Service life.* A plot of CBR versus coverages for the uniform-coverage traffic is shown in plate 8. The points plotted are the rated CBR values listed in table 2 for the clay subgrades and the corresponding number of traffic coverages. From previous tests on landing mats, it has been established that the CBR-coverage relation for landing mat is essentially a straight line when plotted to a log-log scale. Therefore, the linear projection through the failure point in plate 8 indicates the CBR required to support a 27,000-lb single-wheel load with 400-psi tire inflation pressure for various coverage levels. There was only one failure point (298 coverages and 4.2 CBR) obtained in this investigation; therefore, by use of the CBR formulas described in WES Miscellaneous Paper No. 4-615,* the indicated CBR required to support 188 coverages of traffic is approximately 3.7.

39. The CBR design curve shown in plate 9 was developed for the Harvey 1- by 6-ft nonwelded mat. This design curve was computed for 188 coverages of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi. The lower curve is the standard flexible pavement design curve. The curve for the Harvey mat was developed as follows. In plate 8 it is shown that a subgrade with a CBR of 3.7 will support the 27,000-lb wheel load for 188 coverages when surfaced with Harvey 1- by 6-ft nonwelded mat. It can be seen from plate 9 that a flexible pavement design based on a subgrade of 3.7 CBR would require 20 in. of base course. In prior similar studies, CBR design curves have been developed by merely reducing standard curve thicknesses by the thickness pertaining to the 188-coverage service life (20.0 in. in this case). This considers that the effective thickness of a mat plus a strengthening layer beneath it will be equal to the total thickness of an equivalent pavement structure. However, studies being conducted at WES of soil thickness requirements beneath landing mat indicate that the effective thickness of the mat plus the strengthening layer is only 80 to 85 percent of the simple sum of the two thicknesses. Therefore, the CBR design curve for the Harvey 1- by 6-ft nonwelded mat, also shown in plate 9, was obtained by establishing the layer thickness required so that when the total thickness of the underlying layer plus the effective mat thickness was reduced by 20 percent, it yielded a satisfactory effective combined thickness. The curve is presented tentatively pending the outcome of further study of strengthening layers under landing mat.

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* C. D. Burns and W. B. Fenwick, "Development of CBR Design Curves for Harvey Aluminum Landing Mat," Miscellaneous Paper No. 4-615, Jan 1964, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Single-Line Traffic

40. *Test results.* A summary of the test results from the single-line traffic is presented in table 2. This table shows the same type of data as previously discussed for the uniform-coverage traffic tests in paragraph 36. From this table, it can be noted that the mat in both items 1 and 2 was considered satisfactory with no failures or breaks at the end of traffic.

41. *Service life.* No plot of CBR versus passes of the 27,000-lb single-wheel load applied in a single track is shown since no mat planks had failed when traffic was stopped at 1600 passes. The data obtained indicate that a subgrade with a 4.6 CBR will support more than 1600 passes of the test load wheel.

TEST SECTIONS 2 AND 2a, 2- BY 6-FT MAT

42. During the early stages of traffic, severe dishing, which indicates internal damage, was noticed in test sections 2 and 2a. Traffic was stopped after 16 coverages on test section 2, and after 26 coverages on test section 2a because of the severe dishing. This damage was caused by extrusion defects, not by the nonwelded joint configuration. The mat used in these test sections was taken up and shipped back to the fabricator.

TEST SECTION 3, 2- BY 12-FT MAT

Test Results

43. A summary of the test results is presented in table 2. The data presented in this table are described in paragraph 36. Item 2 withstood 187 coverages before failure, and item 3 failed at 160 coverages. Although item 2 withstood 27 coverages more than item 3, there was a similarity in performance of the two items. In item 2, there were 18 C-rail splits and 20 planks with apparent rib damage, and in item 3 there were 19 C-rail splits and 18 planks with apparent rib damage. Both items were failed due to broken ribs and C-rails located in areas adjacent to the nonwelded end connectors of the mat. It should be noted that all failures and breaks that occurred during the uniform-coverage traffic were located at or adjacent to an end joint.

Service Life

44. A plot of CBR versus coverages for the uniform-coverage traffic is shown in plate 10. The points plotted are the rated CBR values listed in table 2 for the clay subgrades and the corresponding number of coverages at the end of traffic. The indicated CBR of 4.4 required to support 188 coverages was obtained by using the technique described in WES Miscellaneous Paper No. 4-615.* A CBR design curve was also developed for the Harvey 2- by 12-ft and 2- by 12-ft modified mats (plate 9). This design curve was computed for 188 coverages of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi and developed as explained in paragraph 39, except that the data from plate 10 were used instead of the data from plate 8. Since analysis of the performance and breakage data indicated little difference between these two types of mat, it was felt that a single CBR design curve that would represent both mats could be developed from the failure data.

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* Burns and Fenwick, op. cit., p 13.

PART VI: DISCUSSION AND CONCLUSIONS

DISCUSSION

45. From plate 8, it can be seen that a subgrade of 3.7 CBR is required under the Harvey 1- by 6-ft nonwelded mat to support 188 coverages of traffic distributed uniformly over a 10-ft-wide lane. Compared with the subgrade strength to support 188 coverages of traffic on the Harvey welded AM2 mat,* the 1- by 6-ft nonwelded mat required a 0.4 lower CBR. Single-line traffic (1600 passes) was run on this mat without failure on a subgrade of 4.6 CBR.

46. Three test sections were surfaced with the Harvey 2-ft-wide nonwelded mat. Only uniform coverage traffic was applied to the 2-ft-wide mat. Traffic was stopped after 16 and 26 coverages on test sections 2 and 2a, respectively, due to severe internal damage of the 2- by 6-ft mat. The damage occurring in these test sections was caused by extrusion defects, not by the nonwelded joint configuration. From plate 9, it can be seen that a subgrade strength of 4.4 CBR under the 2- by 12-ft mat is required to support 188 coverages of traffic distributed uniformly over a 10-ft-wide lane. This is about 0.5 CBR more than that required to support the same amount of traffic on the Harvey welded mat reported previously.* All the mat failures in this test were caused by severe dishing, indicating rib damage, located in areas adjacent to end joints.

47. The end joints of the 1-ft-wide mat performed better than those of the 2-ft-wide mat because they were about twice as rigid, or stiff. Although all plank failures of the 1-ft-wide mat were attributed to C-rail splits and broken ribs located at the ends of the mat planks, they were not caused by unsatisfactory performance of the nonwelded end joints. The only damage occurring to the end joints was small skin tears and end-curl splits. After traffic on both the 2- by 12-ft mat and the modified 2- by 12-ft mat in test section 3, the dishes at the end joints caused by rib failures of these planks measured 1/2 in. or more on all the planks in the traffic lane. Although there were no failures due to broken end connectors, the nonwelded 2-ft-wide mat is not an improvement over standard AM2 mat with welded end joints because of the reduced stiffness of the 2-ft-long nonwelded end-joint connector.

CONCLUSIONS

48. Based on the data presented in this report, the following conclusions are drawn:

   a. The Harvey 1- by 6-ft, 2- by 12-ft, and modified 2- by 12-ft nonwelded aluminum mat will sustain 1600 cycles (188 coverages) of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having minimum CBR's of 3.7, 4.2, and 4.4, respectively, throughout the period of traffic.

   b. The Harvey 1- by 6-ft nonwelded aluminum landing mat will sustain 1600 passes of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi in a single path (located 1-1/2 ft or more from the mat end joints) when placed on a subgrade having a CBR of 4.6 or greater throughout the period of traffic.

   c. General behavior of the mat in these tests was materially affected by the nonwelded end-joint configuration of the mat planks. There were no failures of the 1- by 6-ft mat attributed to the nonwelded end joints. The 1- by 6-ft Harvey nonwelded mat will sustain 188 coverages of traffic on a slightly lower subgrade strength than the standard AM2 mats previously tested at WES. The 2- by 12-ft nonwelded mat performed

* W. B. Fenwick, "Evaluation of Harvey Modified AM2 Landing Mat," Miscellaneous Paper No. 4-747, Oct 1965, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

about the same as AM2 mat previously tested at the WES. The 2-ft-wide mat was not an improvement over the mat with welded-type end-connector joints because the rigidity of the end joints was reduced, causing severe dishing and mat breakage at the end joints. The 2- by 6-ft nonwelded mat investigated failed early in the traffic period because of extrusion defects, not because of the nonwelded joint configuration.

d. The extended web of the locking bar used with the modified mat, which fitted into the notch in the male side connector, kept the mat planks from moving laterally but did not reduce the mat damage occurring at the end joints.

Table 1

Summary of CBR, Water Content, and Dry Density Data

Test Lane	Test Section and Item	Subgrade Material	Before Traffic: Pit No	Before Traffic: Depth in.	Before Traffic: CBR	Before Traffic: Water Content %	Before Traffic: Dry Density pcf	Traffic Passes or Coverages	After Traffic: Pit No	After Traffic: Depth in.	After Traffic: CBR	After Traffic: Water Content %	After Traffic: Dry Density pcf
1	1.1	Heavy clay	1	0	3.3	31.1	87.4	188	3	0	4.9	30.4	88.7
				6	4.0	30.0	88.5			6	4.0	30.7	88.4
				12	4.6	25.3	93.5			12	4.4	24.8	96.9
								298	7	0	4.3	31.0	89.0
										6	3.6	29.3	90.8
										12	5.2	28.9	91.4
1	1.2	Heavy clay	2	0	7.0	27.8	91.2	188	4	0	9.0	27.6	90.8
				6	7.0	28.0	90.5			6	6.0	27.9	90.7
				12	8.0	27.8	90.8			12	7.0	23.4	95.9
								298	8	0	10.0	27.9	93.3
										6	6.0	28.0	91.8
										12	8.0	27.5	92.3
2	1.1	Heavy clay	1	0	3.3	31.1	87.4	1600	5	0	5.7	30.4	88.8
				6	4.0	30.0	88.5			6	4.9	28.8	91.0
				12	4.6	25.3	93.5			12	5.0	26.2	96.2
2	1.2	Heavy clay	2	0	7.0	27.8	91.2	1600	6	0	10.0	27.5	93.2
				6	7.0	28.0	90.5			6	8.0	27.4	91.3
				12	8.0	27.8	90.8			12	8.0	25.9	90.3
1	3.2	Heavy clay	3 and 4	0	3.6	29.0	91.1	187	8	0	4.2	28.1	92.9
				6	4.2	28.0	91.6			6	5.1	27.0	91.6
				12	3.9	27.8	90.6			12	4.3	27.9	91.1
1	3.3	Heavy clay	5 and 6	0	3.6	27.8	91.4	160	9	0	4.2	28.6	90.4
				6	4.0	28.3	91.8			6	4.1	27.7	92.5
				12	4.7	27.1	92.5			12	4.3	27.7	92.1

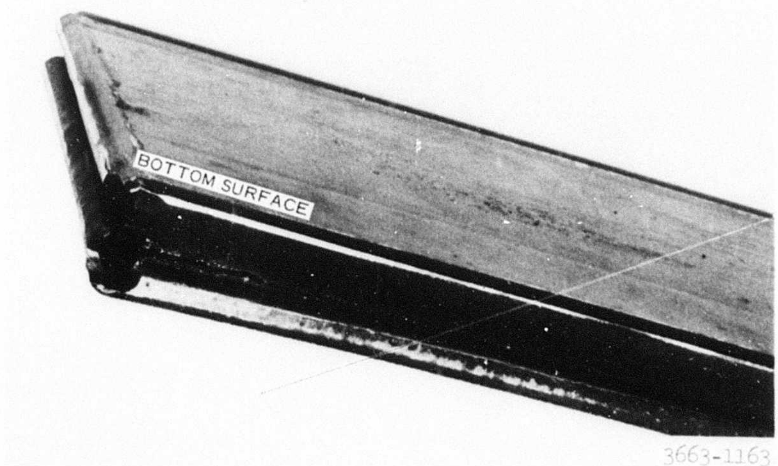
Note: In section 1, lane 1, data were obtained after 188 coverages, the minimum specified in the service life criteria, and after failure at 298 coverages. In section 2, no subgrade data were taken because of the short duration of the traffic tests.

Table 2

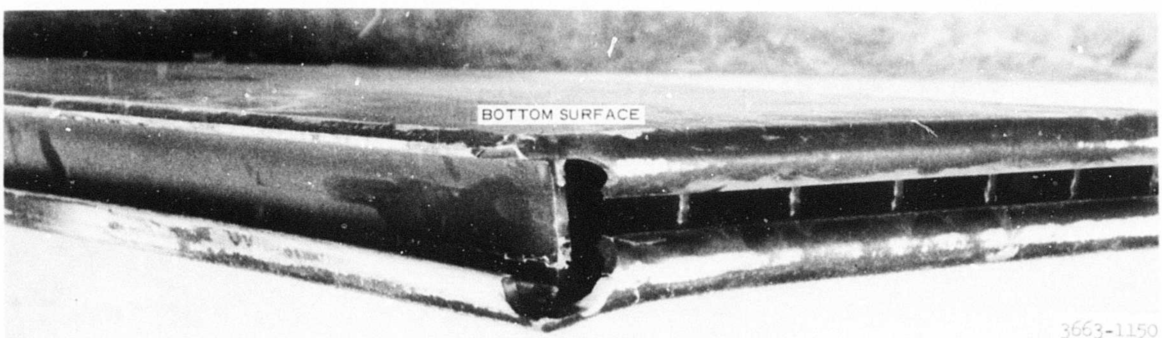
Summary of Uniform-Coverage and Single-Line Traffic Test Results

Test Lane	Test Section and Item	Type of Plank	Rated Subgrade CBR	No. Planks Subjected to Traffic	No. of Plank End Joints in Traffic Lane	Traffic Coverages or Passes	Mat Breakage: Top Skin Tears	Mat Breakage: C-Rail Splits	Mat Breakage: End-Curl Splits	Mat Breakage: Notch Breaks Top	Mat Breakage: Notch Breaks Bottom	Mat Breakage: Planks with Broken Ribs	Mat Breakage: Planks with Apparent Core Damage	Mat Breakage: Planks in Which Core Failed	Total No. Planks Failed	Maximum Mat Deflection in.	Rating of Item
1	1-1	1- by 6-ft	4.2	50	60	0	--	--	--	--	--	--	--	--	--	0.9	--
						188	--	31	--	--	--	--	--	--	--	1.1	Fair
						298	9	60	20	--	--	51	--	10	10	1.0	Failed
1	1-2	1- by 6-ft	7.0	46	56	0	--	--	--	--	--	--	--	--	--	0.7	--
						188	--	--	--	--	--	--	--	--	--	0.7	Good
						298	--	54	4	--	--	21	--	2	2	0.6	Fair
2	1-1	1- by 6-ft	4.6	20		0	--	--	--	--	--	--	--	--	--	0.9	--
						1600	--	--	--	--	--	--	--	--	--	1.4	Good
2	1-2	1- by 6-ft	8.0	19		0	--	--	--	--	--	--	--	--	--	0.6	--
						1600	--	--	--	--	--	--	--	--	--	0.8	Good
1	3-2	2- by 12-ft modified	4.2	30	20	0	--	--	--	--	--	--	--	--	--	0.8	--
						68	--	--	--	--	--	--	2	--	--	--	--
						100	--	--	--	--	--	--	5	--	--	--	--
						187	1	18	--	5	1	19	20	11	11	0.8	Failed
1	3-3	2- by 12-ft	4.2	30	20	0	--	--	--	--	--	--	--	--	--	0.8	--
						68	--	2	--	--	--	--	6	--	--	--	--
						100	1	15	--	--	--	--	6	--	--	--	--
						160	16	19	--	--	--	18	18	10	10	0.9	Failed

Photograph 1. Test section 1 prior to traffic

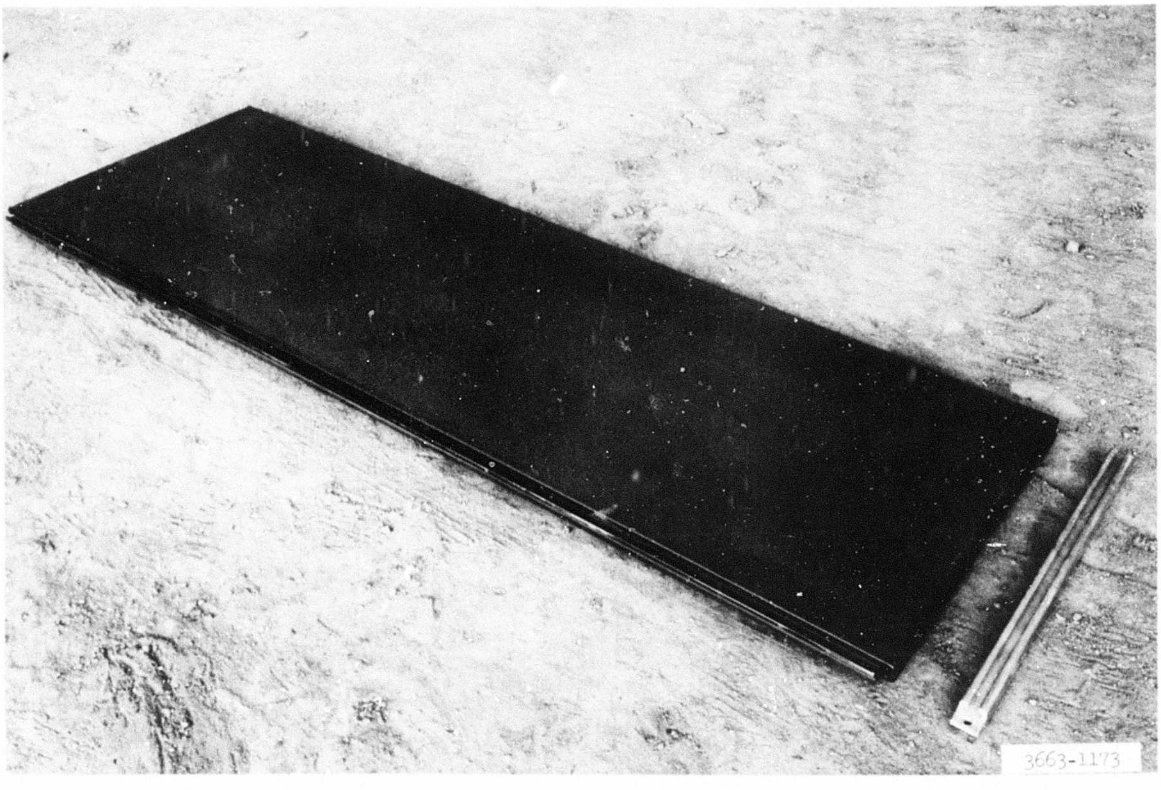


Photograph 2. C-rail split

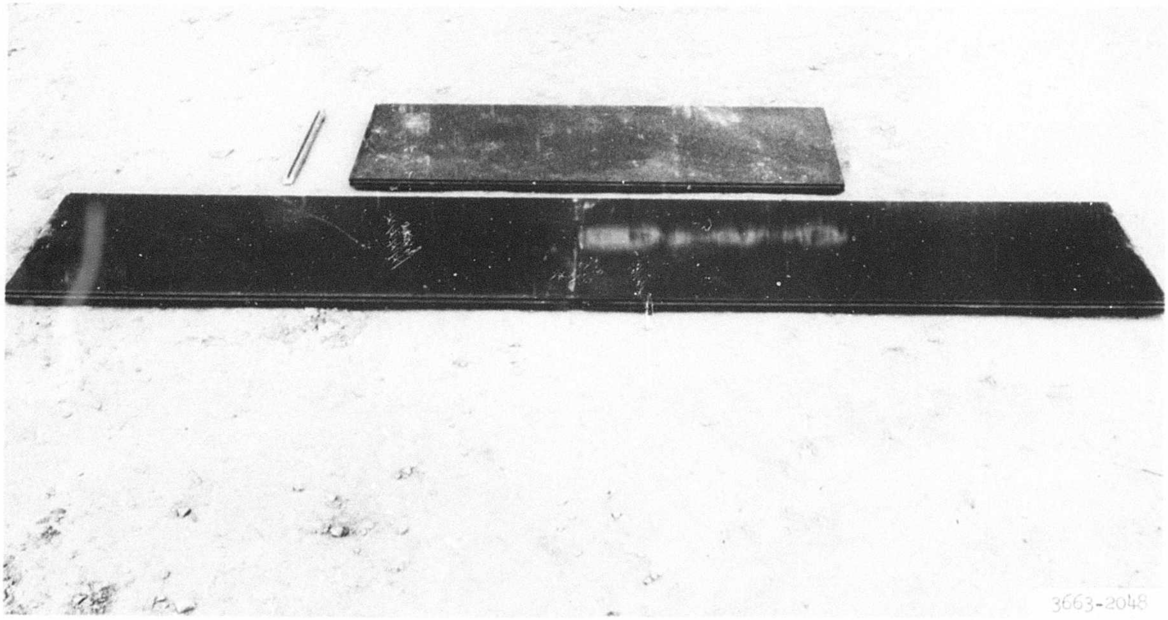


Photograph 3. End-curl split

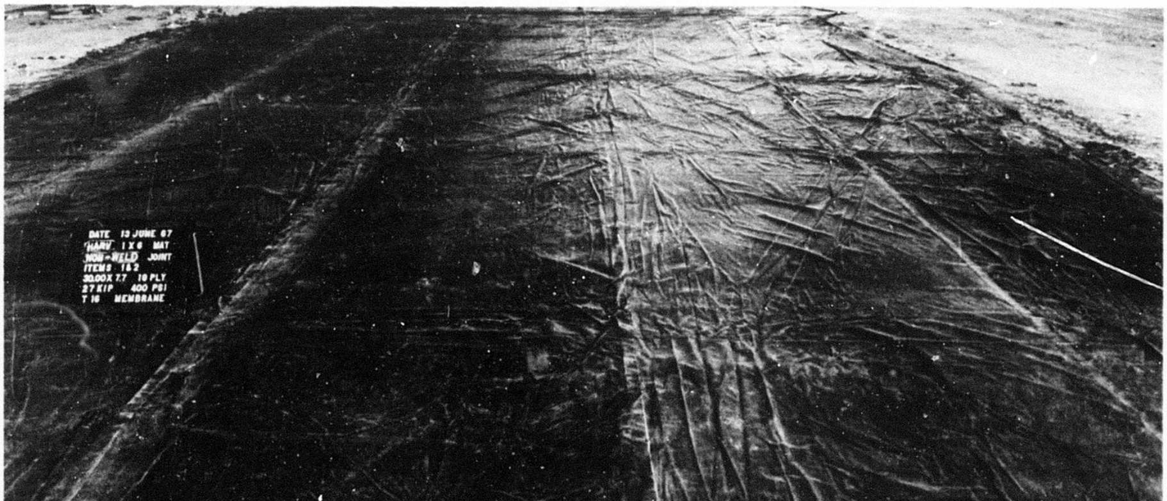
Photograph 4. A 1- by 6-ft mat plank and locking bar



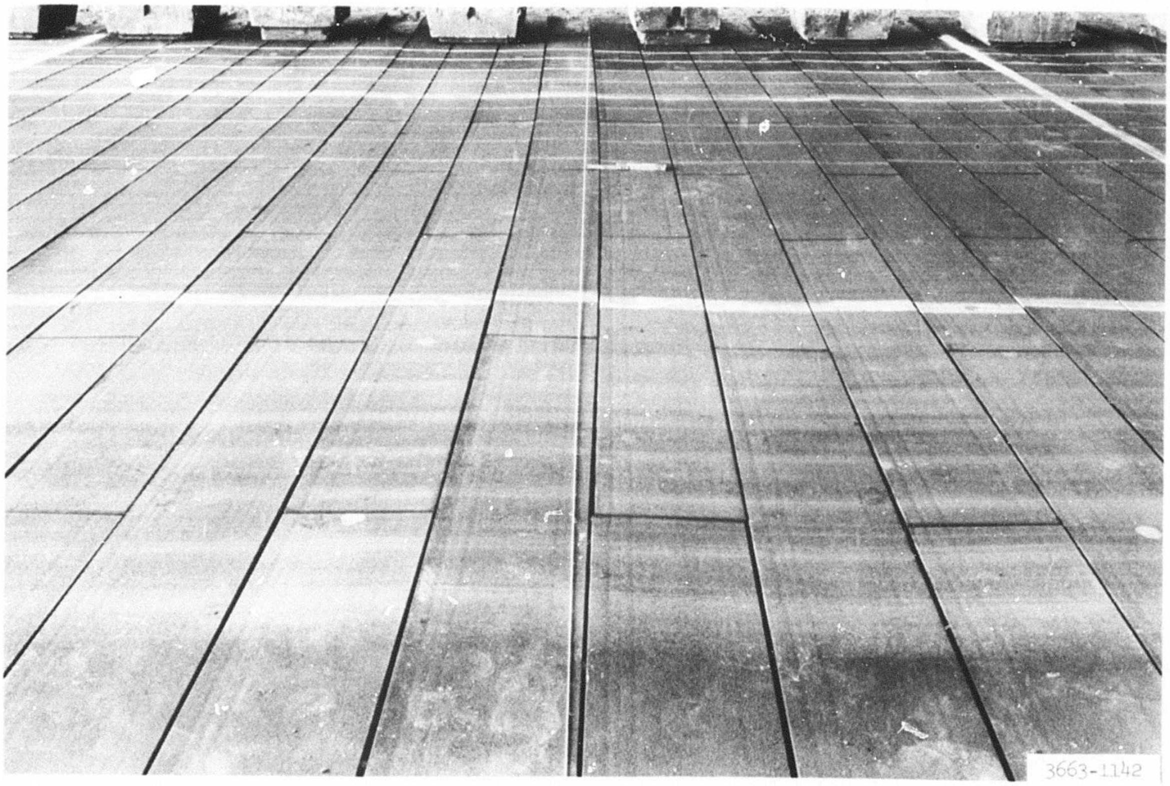
Photograph 5. A 2- by 6-ft mat plank and locking bar



Photograph 6. Locking bar and full-size and half-size planks of modified 2- by 12-ft mat

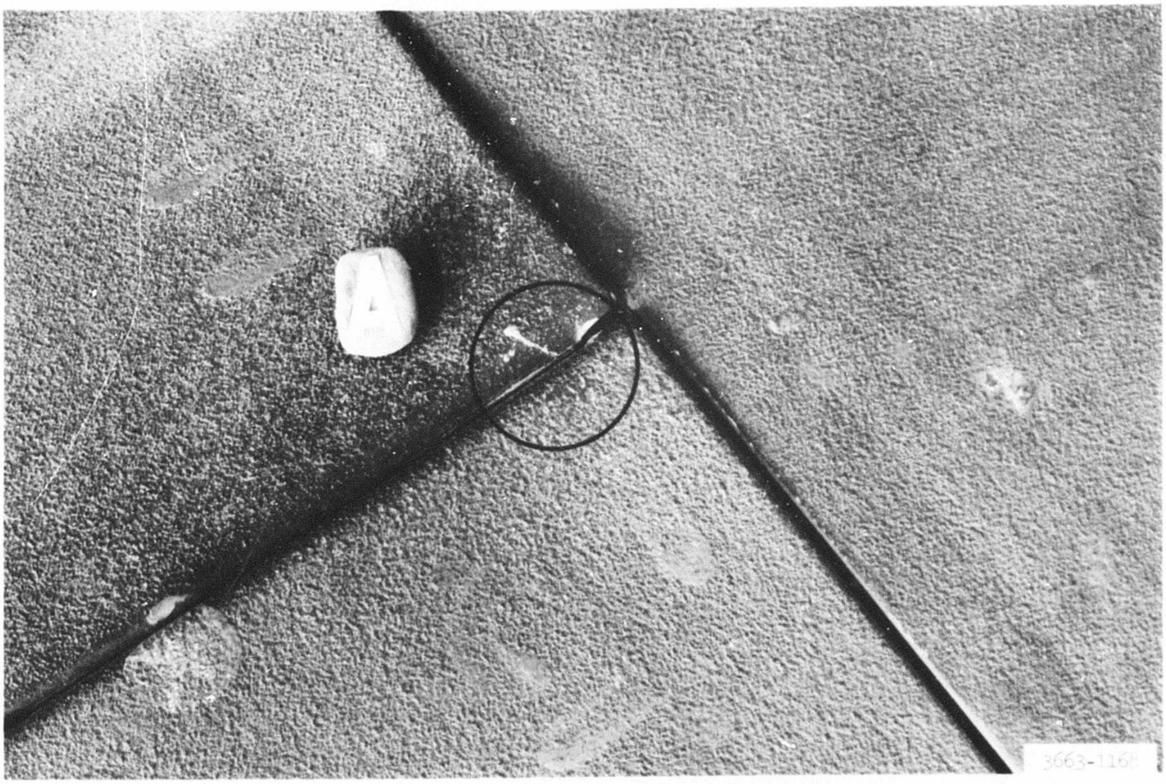


Photograph 7. Subgrade covered with T16 membrane

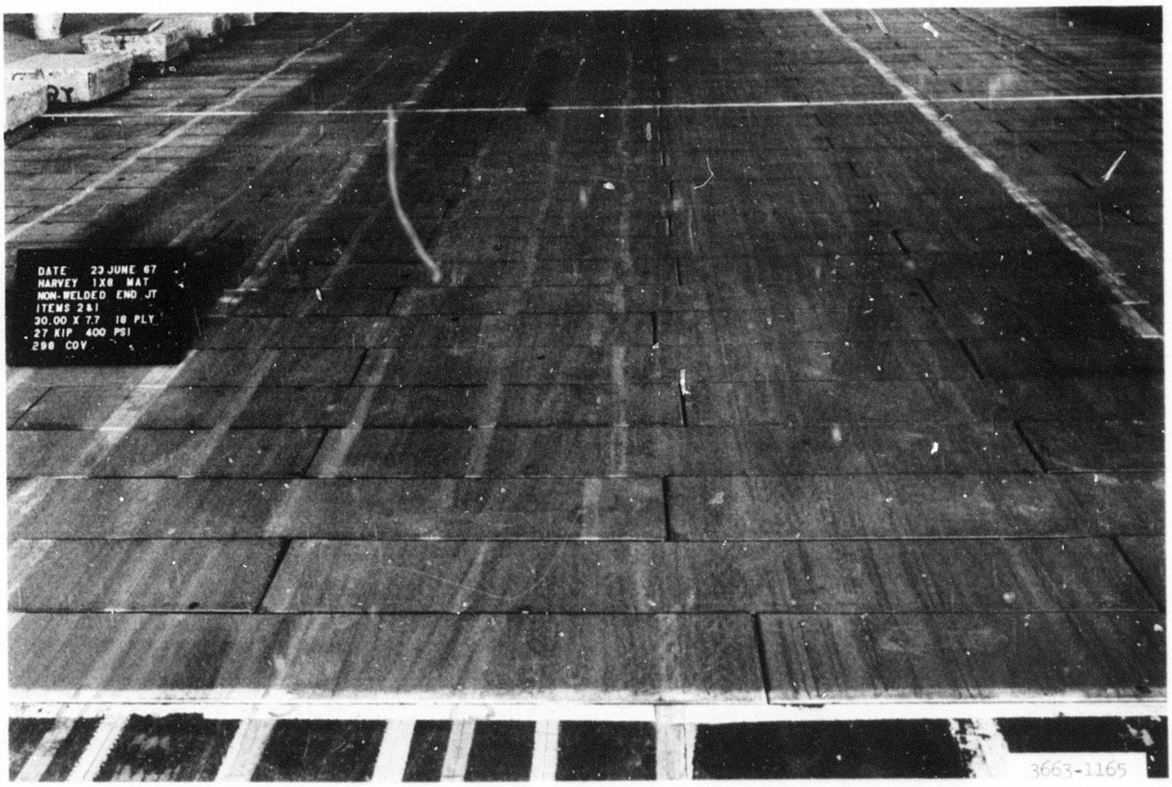


Photograph 8. Bow (2-1/2-in.) in mat after 100 coverages on items 1 and 2

Photograph 9. Test section 1 after 188 coverages



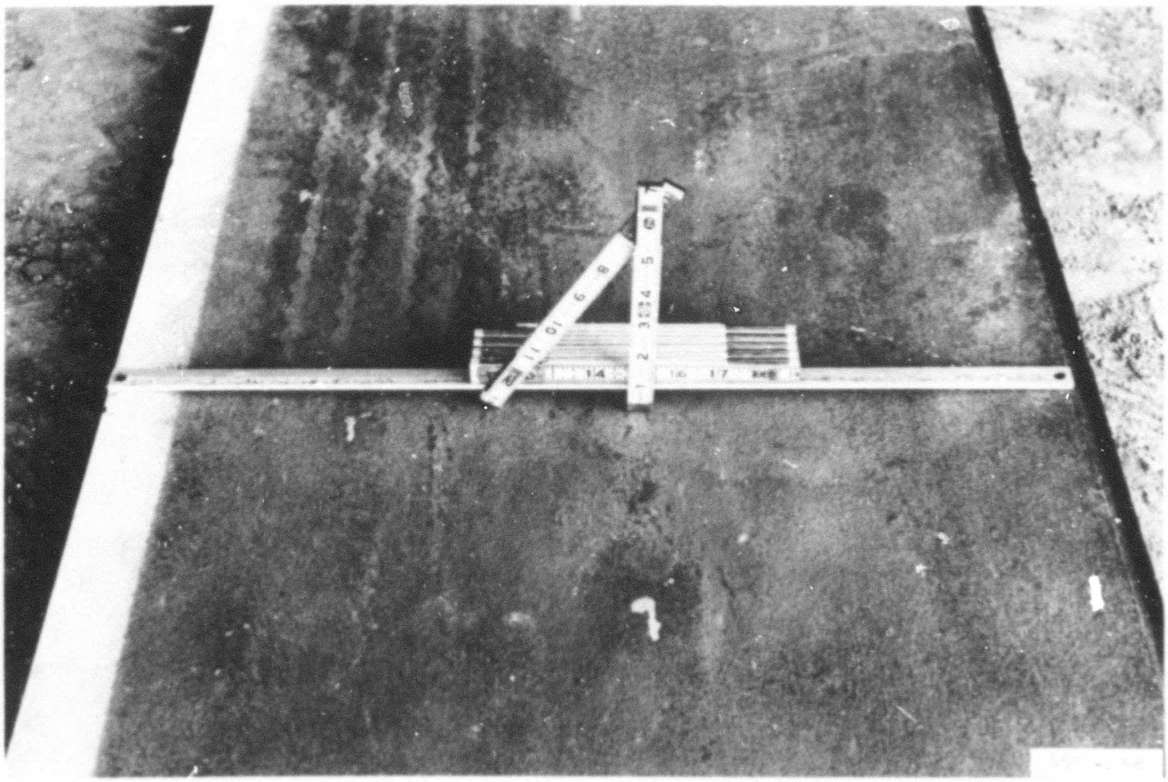
Photograph 10. Skin tear in plank 11 after 298 coverages; item 1, lane 1



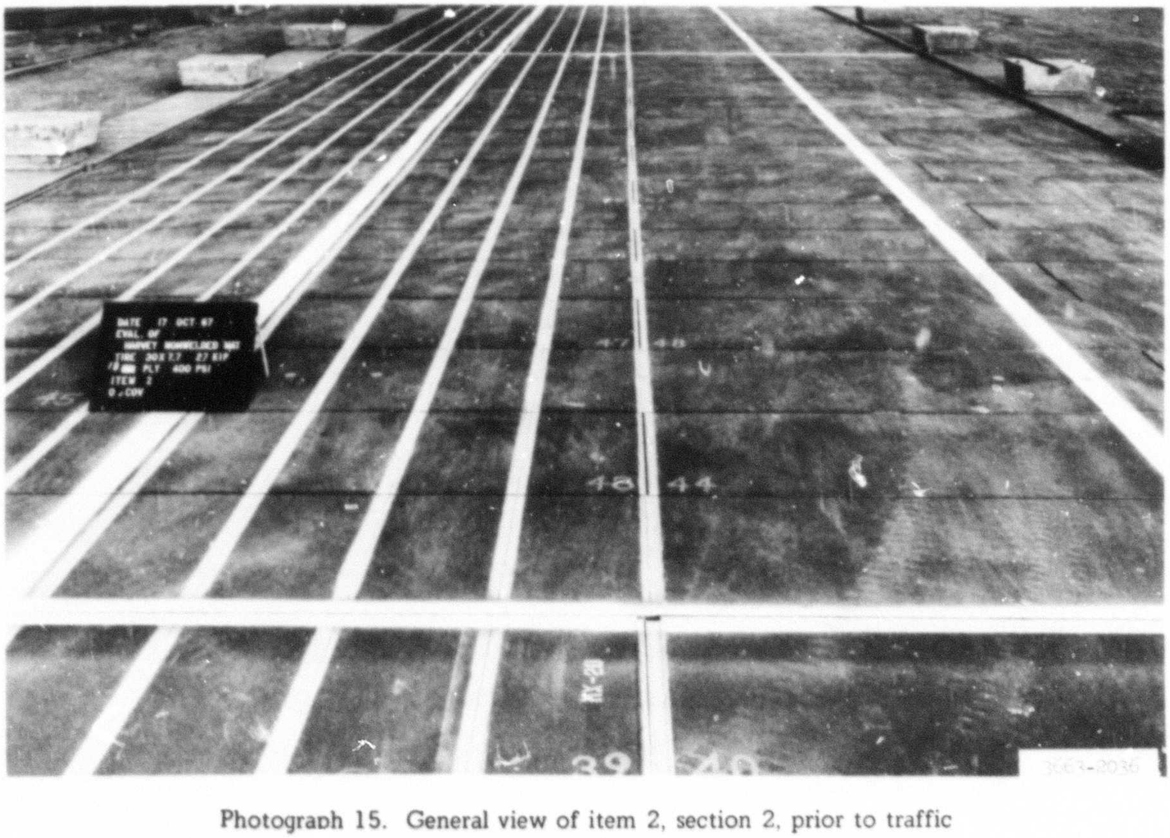
Photograph 11. Test section 1, lane 1, after 298 coverages (failure)

Photograph 12. Item 1, lane 2, prior to single-line traffic

Photograph 13. Test section 1, lane 2, after 1600 passes



Photograph 14. Dish in plank 2 after 16 coverages; test section 2, item 1, lane 1

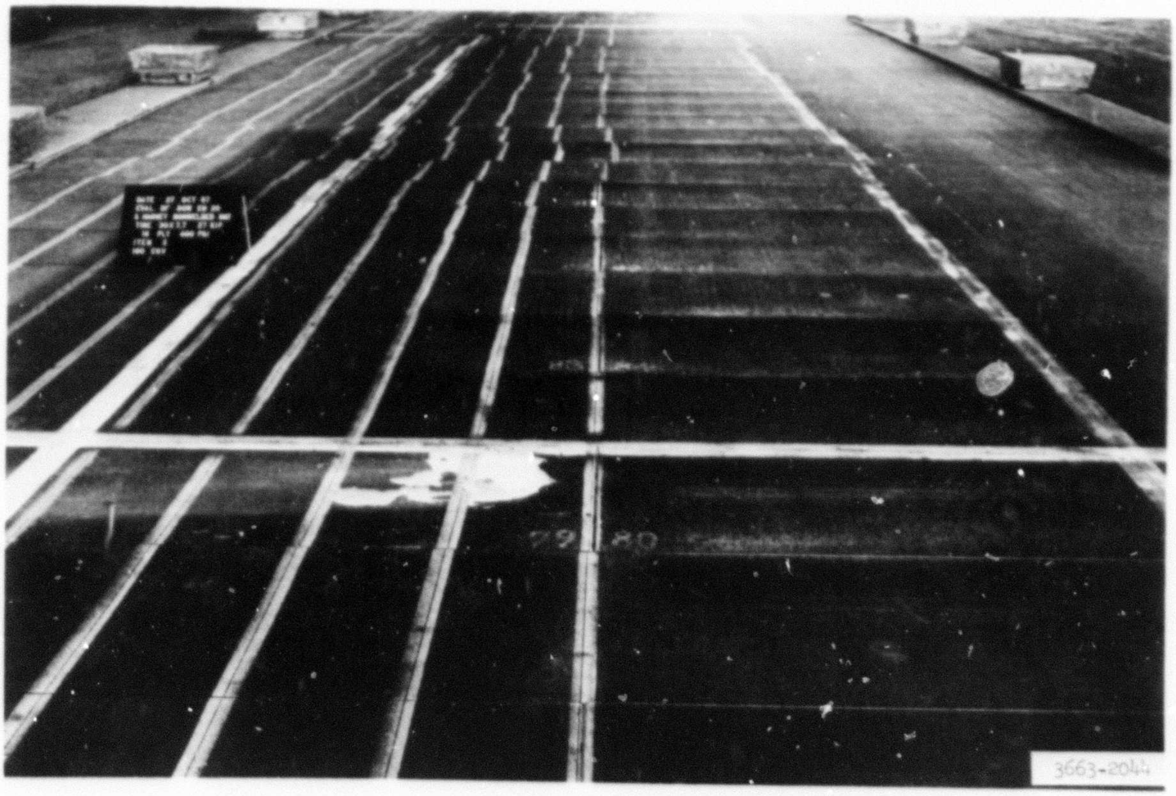


Photograph 15. General view of item 2, section 2, prior to traffic

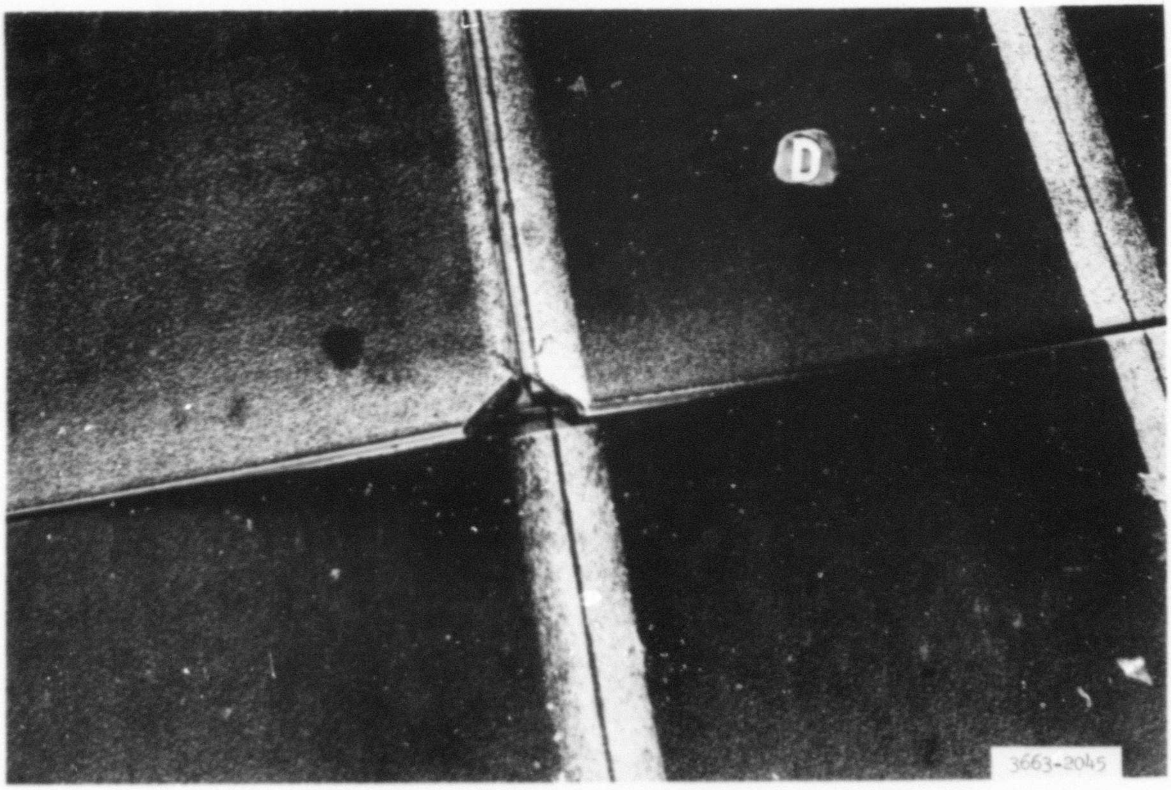
Photograph 16. General view of item 2, section 3, after 187 coverages

Photograph 17. General view of item 3, section 3, prior to traffic

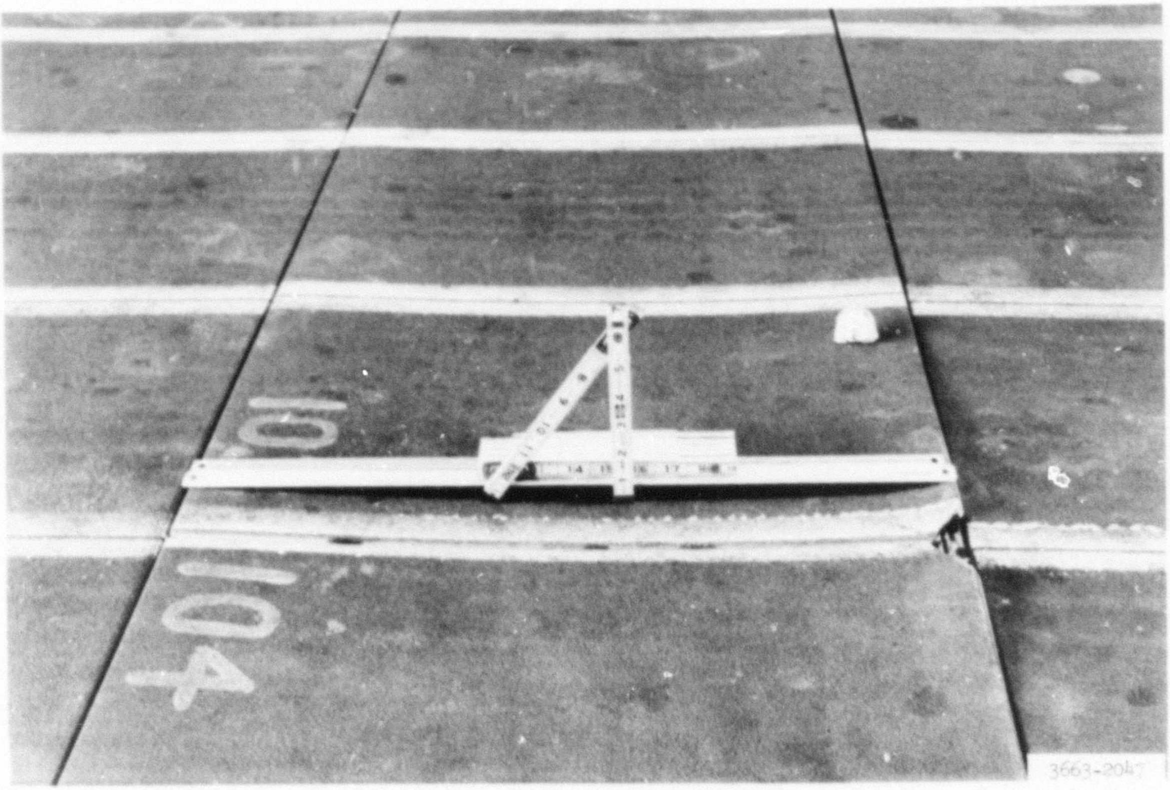
Photograph 18. Lateral movement of the mat planks after 68 coverages of traffic; item 3, section 3



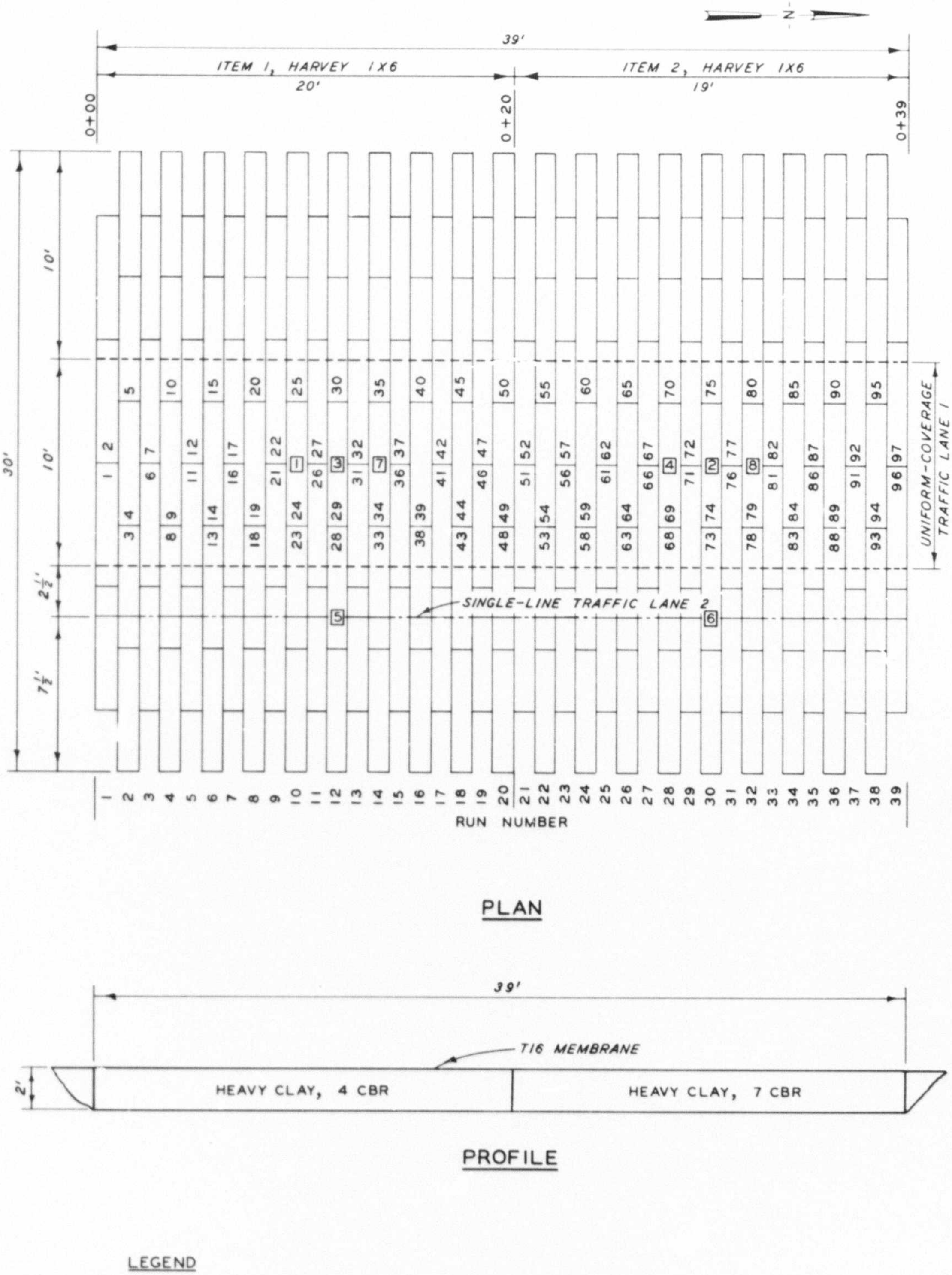
Photograph 19. Item 3, section 3 in background, after 160 coverages of traffic (failure)



Photograph 20. Curl of top lip of C-rail (due to break in C-rail) and break in top skin of the end connector after 160 coverages; item 3, section 3

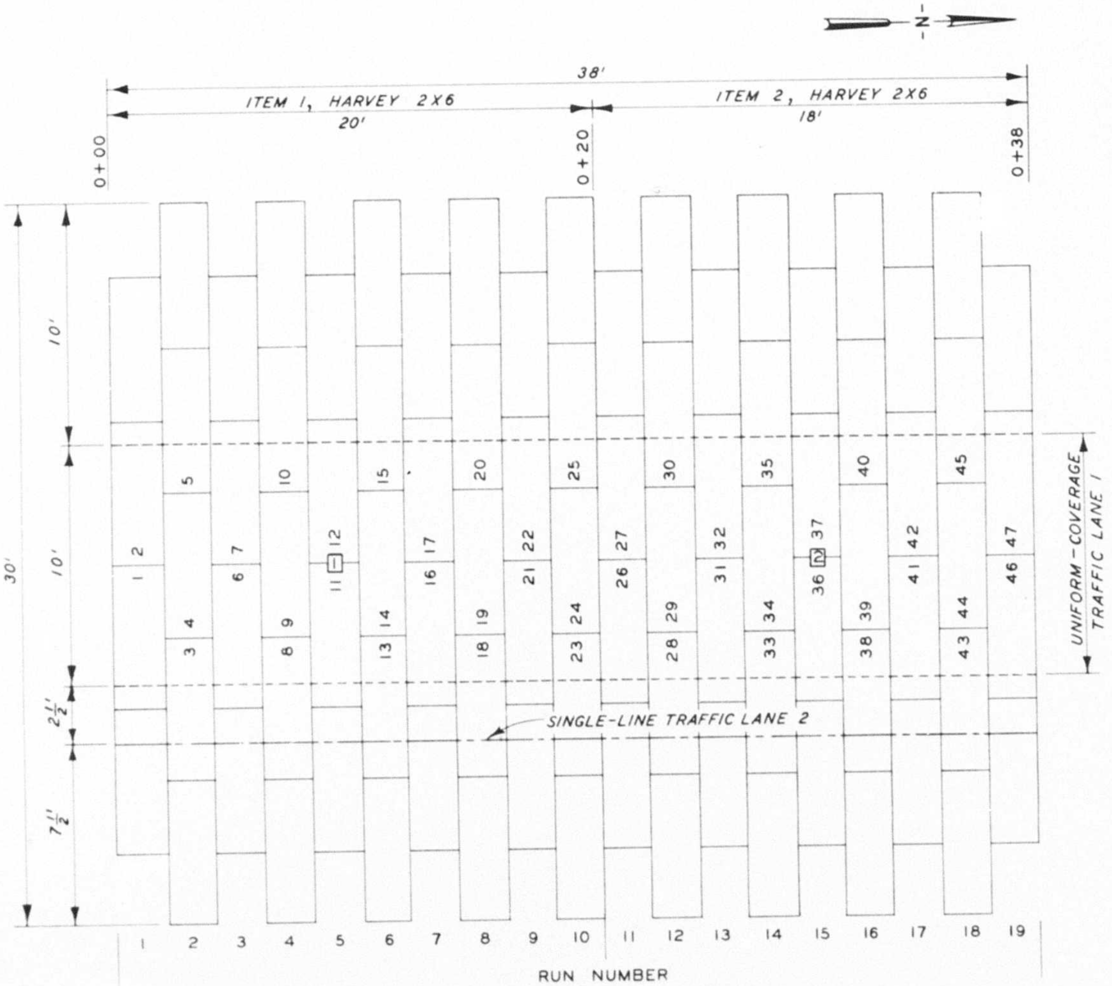


Photograph 21. Dish in plank 103 after 160 coverages; item 3, section 3

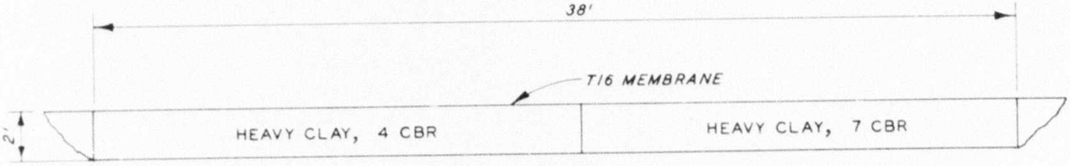


PLAN AND SUBGRADE PROFILE

TEST SECTION 1



PLAN



PROFILE

NOTE: MODIFIED LOCKING BARS WERE USED IN RUNS 3, 4, 5, AND 6.

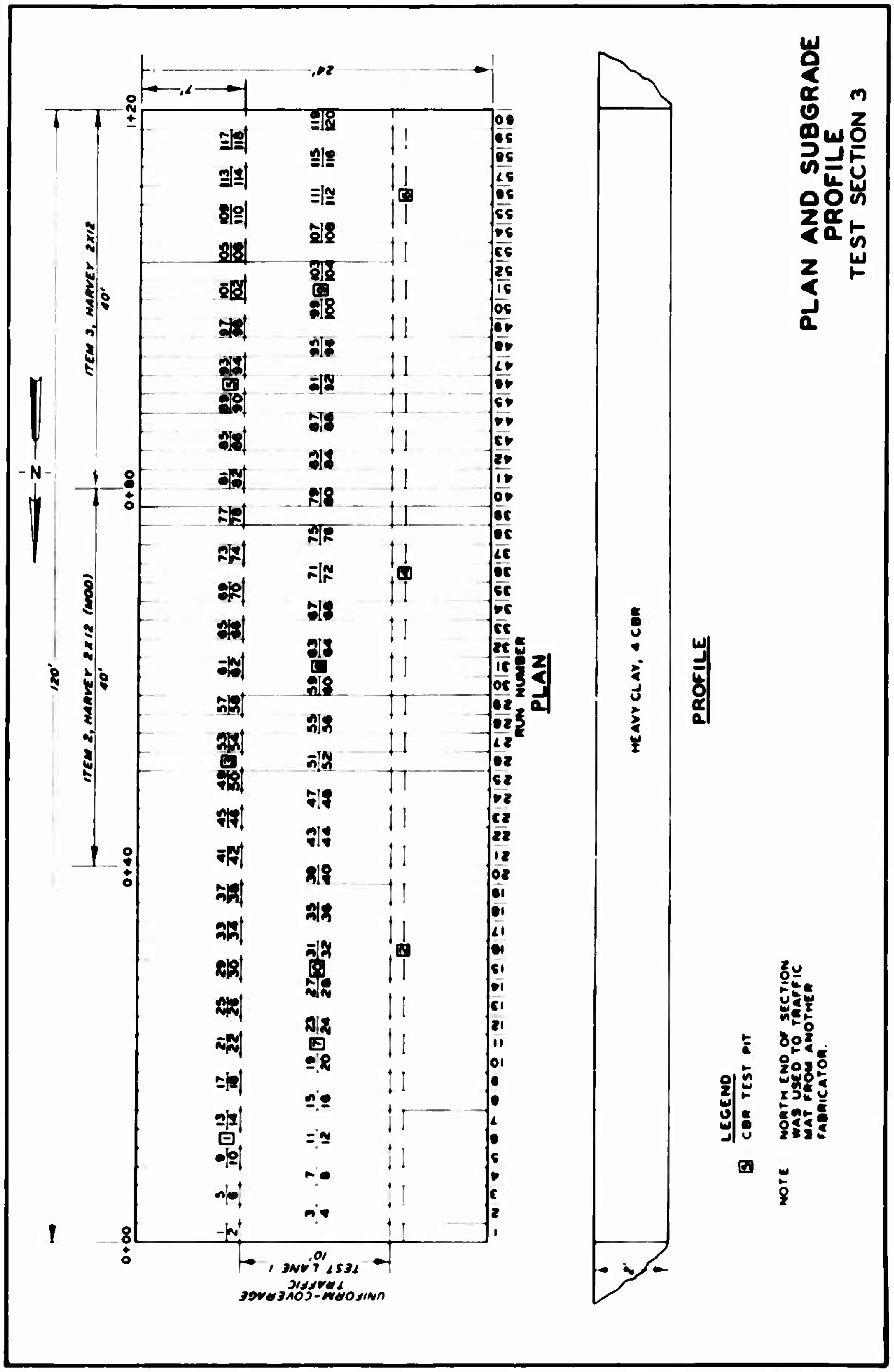
LEGEND

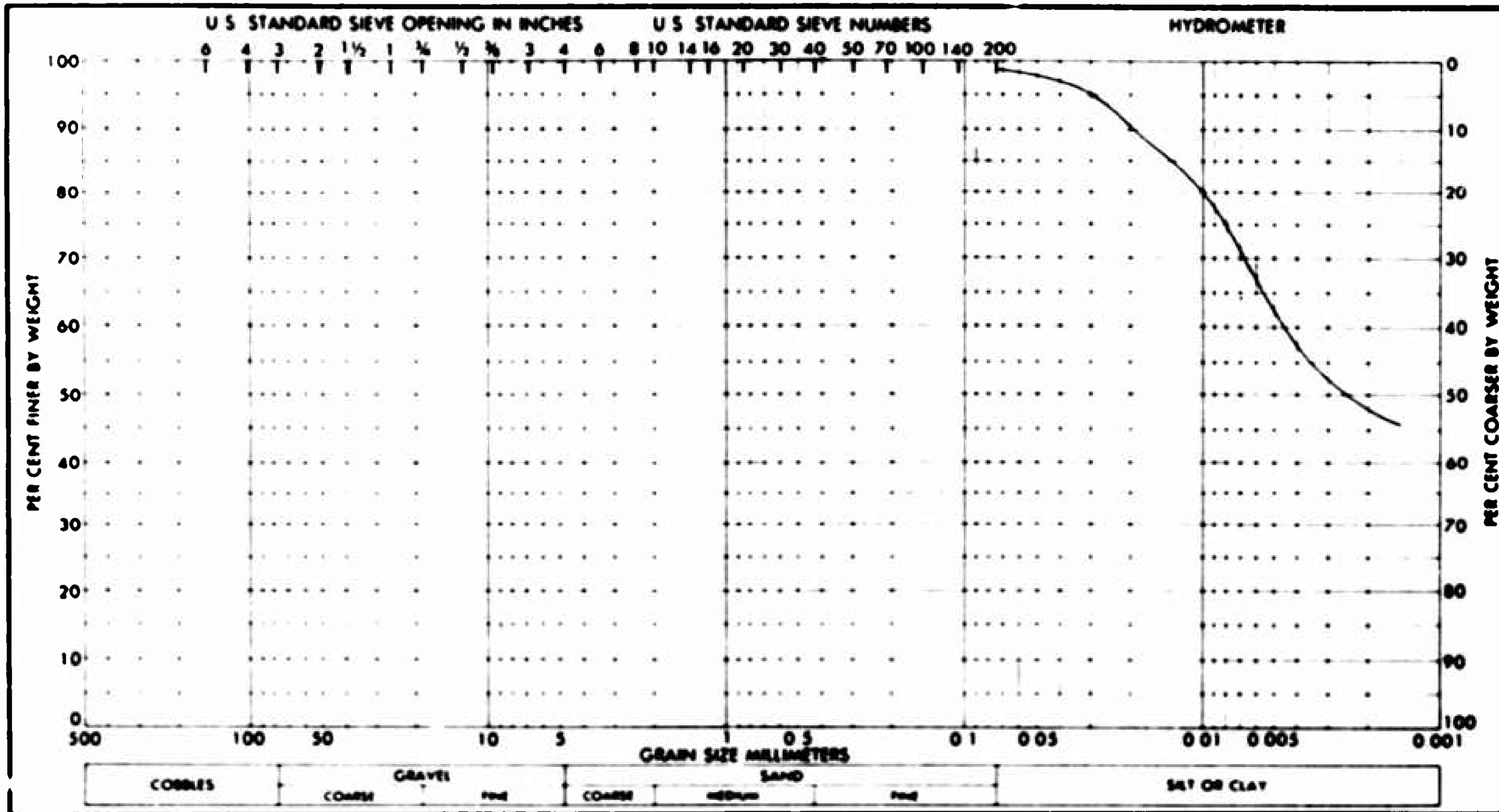
□ CBR TEST PIT

PLAN AND SUBGRADE PROFILE

TEST SECTIONS 2 AND 2-A

PLATE 2

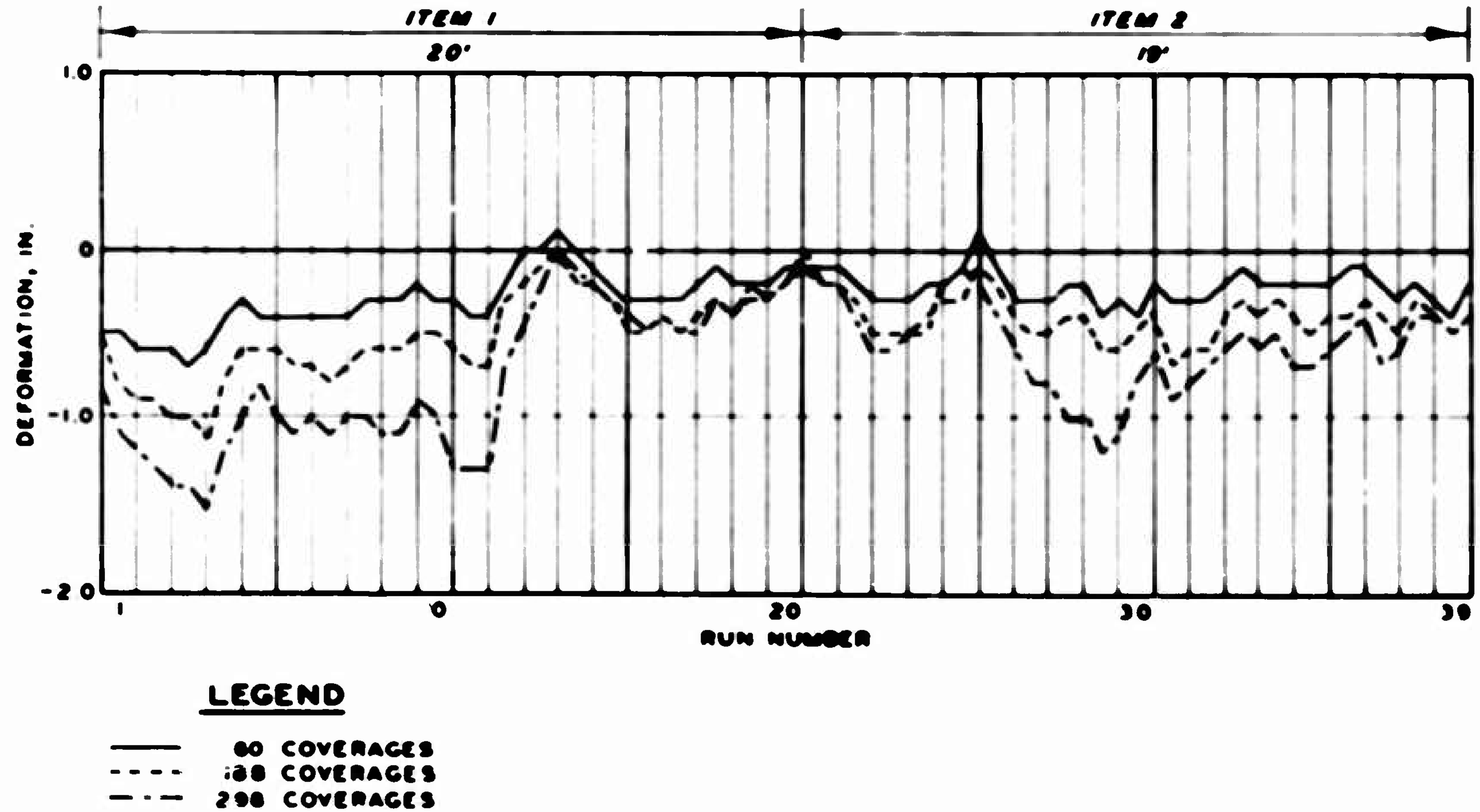

PLAN AND SUBGRADE PROFILE
TEST SECTION 3
N
120'
ITEM 2, HARVEY 2X12 (MOD)
40'
ITEM 3, HARVEY 2X12
40'
0+00
0+40
0+80
1+20
24'
7'
10'
UNIFORM-COVERAGE TRAFFIC TEST LANE 1
RUN NUMBER
PLAN
HEAVY CLAY, 4 CBR
2'
PROFILE
LEGEND
CBR TEST PIT
NOTE NORTH END OF SECTION WAS USED TO TRAFFIC MAT FROM ANOTHER FABRICATOR.



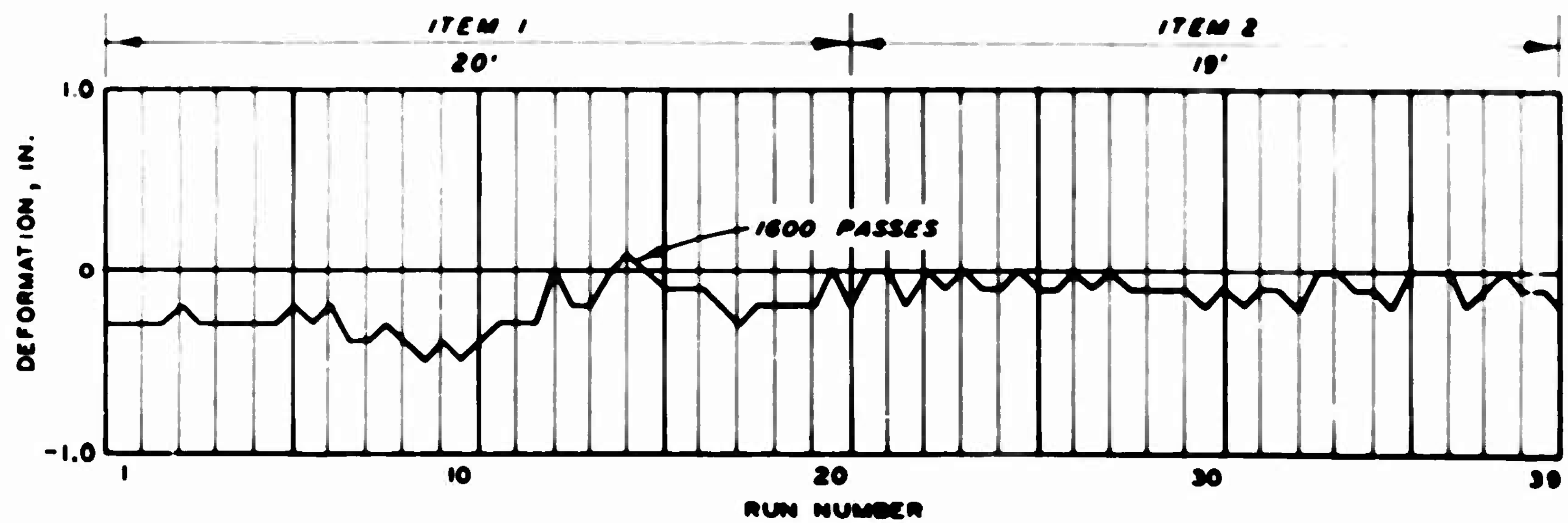
SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
		HEAVY CLAY (BUCKSHOT) (CH)		73	25	48

CLASSIFICATION DATA AND GRADATION

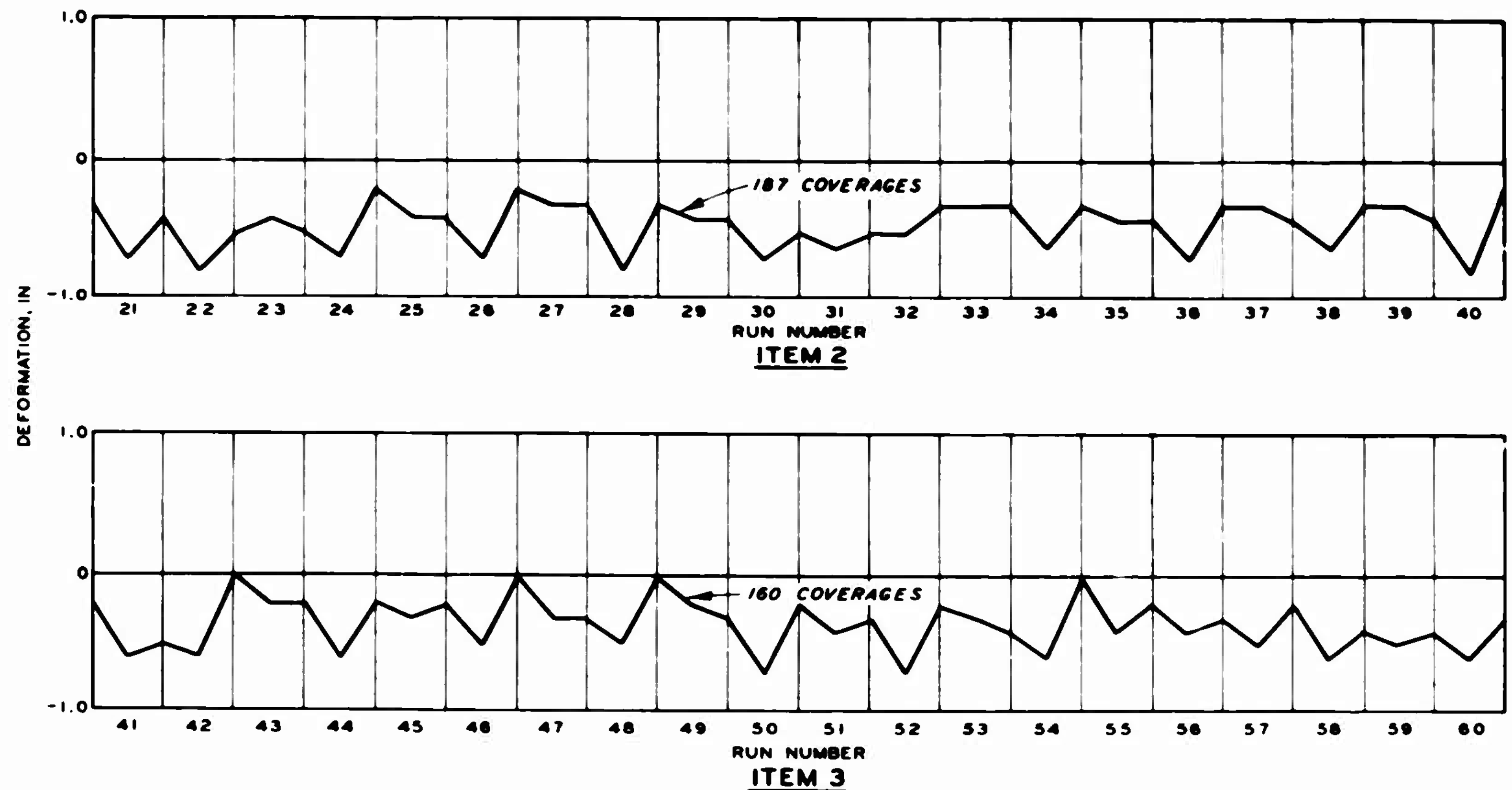
SUBGRADE SOIL



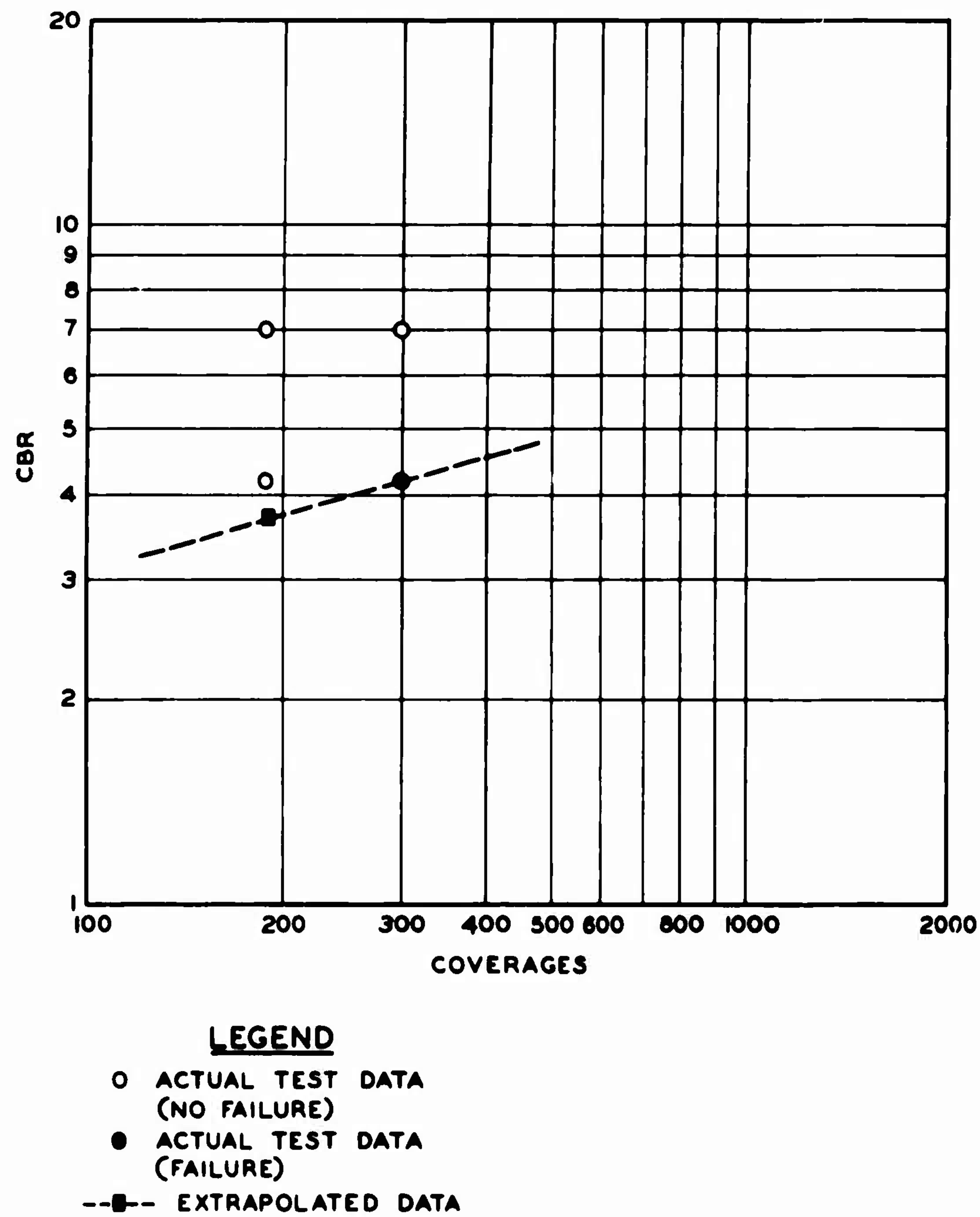
PROFILES ALONG CENTER LINE
UNIFORM-COVERAGE TRAFFIC LANE
TEST SECTION 1



PROFILE ALONG CENTER LINE
SINGLE-LINE TRAFFIC LANE
TEST SECTION 1

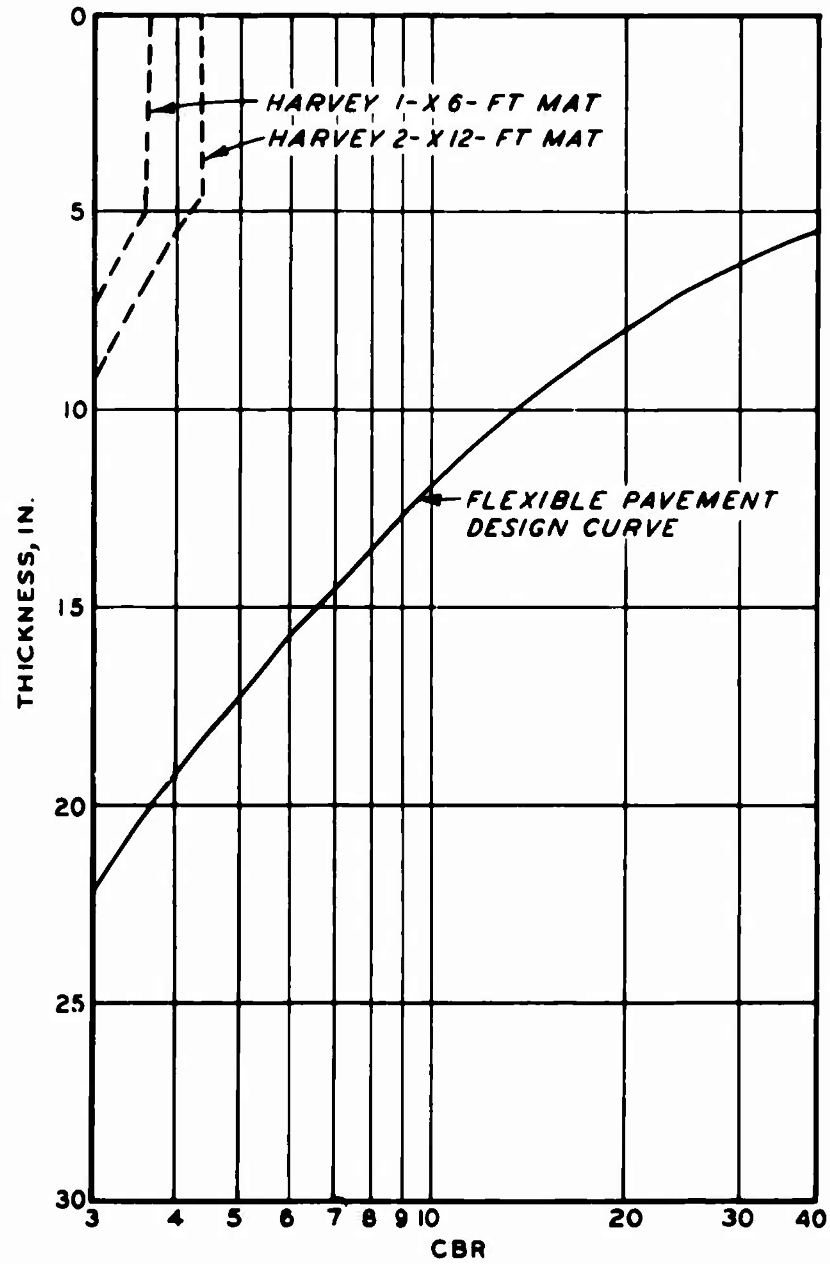


PROFILES ALONG CENTER LINE
UNIFORM-COVERAGE TRAFFIC LANE
TEST SECTION 3

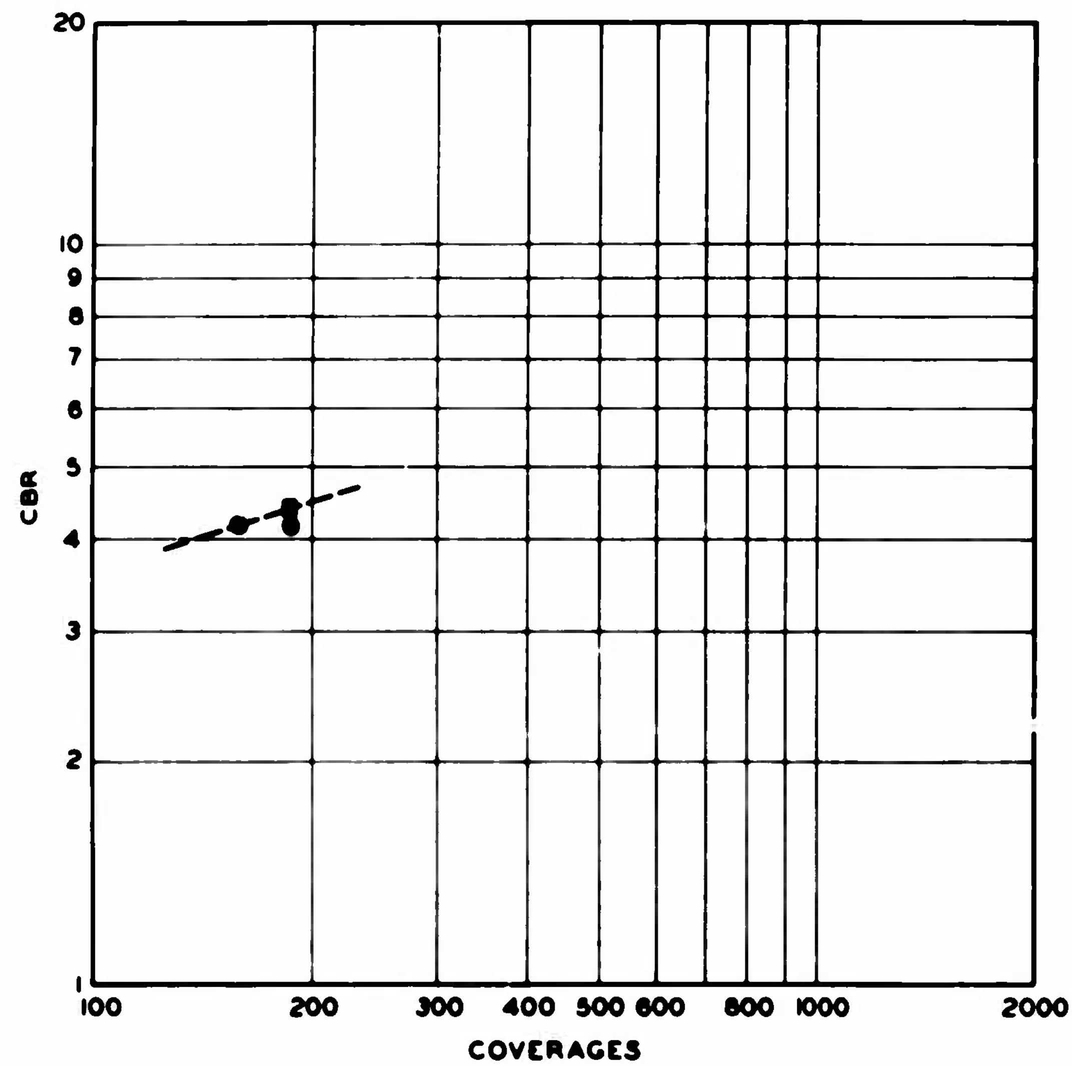


CBR VS COVERAGES

TEST SECTION I
UNIFORM-COVERAGE TRAFFIC



CBR DESIGN CURVE
27,000-LB, SINGLE-WHEEL LOAD
400-PSI TIRE PRESSURE
188 COVERAGES



LEGEND

● ACTUAL TEST DATA (FAILURE)

--■-- EXTRAPOLATED DATA

CBR VS COVERAGES

TEST SECTION 3
UNIFORM-COVERAGE TRAFFIC